

Lin-Lin Chen, Tom Djajadiningrat, Loe Feijs, Simon Fraser, Jun Hu, Steven Kyf n, Dagmar Steffen

# Design and semantics of form and movement

DeSForM 2013

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Lin-Lin Chen, Tom Djajadiningrat, Loe Feijs, Simon Fraser, Jun Hu, Steven Kyffin, Dagmar Steffen

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#### **Dagmar Steffen**

Lucerne University of Applied Sciences and Arts, Switzerland

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#### **Stephan Wensveen**

University of Southern Denmark

# DeSForM 2013

Welcome to Wuxi! Welcome to Jiangnan University! After successful conferences in Europe and Asia, and an exciting and inspiring long trip to New Zealand in 2012, DeSForM comes to China, where the making has been happening and innovation is landing. The School of Digital Media of Jiangnan University is honored to host the 8th international conference on Design and Semantics of Form and Movement.

Wuxi is a beautiful city located in southeast China, being famous for its culture, architecture, waterway transportation and various art forms. It is also one of the birth places of modern Chinese manufacturing and textile industries, having a history of business people involved in modern Shanghai commerce since the early 20th century and a splendid history of over three thousand years. Wuxi claims to be 'the Pearl of Tai Lake'.

Emerging from the Department of Animation in the School of Design and the former Department of Digital Media Technology in the School of Information Technology, the School of Digital Media of Jiangnan University was established in 2009 to meet the strong demands of the increasingly rapid development of digital media industry for high-level design and technical professionals. The school consists of the Digital Arts Department, the Digital Media Technology Department and the Experiment Center. The Experiment Center includes the Digital Virtual Laboratory, the Digital

Imaging Laboratory and The Digital Interactive Technology Laboratory. As one of the first and leading Chinese universities in the discipline of design, Jiangnan University has an ambition in not only continuing leading in traditional design, but also prevailing in designing digital and interactive products and systems. We hope that the DeSForM conference will contribute to this ambition and the new development in this direction.

The DeSForM conference is intrigued by the notion that the nature of things, the essence of what a fabricated object is, was about to be – and really should be – completely and fundamentally questioned, re-defined, and explored. We are proposing some challenging questions, which in some way define the scope and the key themes for the conference; these include

- **The Aesthetic of Interaction & Digital Representation:** What are the key DeSForM insights concerning: Design and meaning, design and aesthetics, new forms, new materials, new media.
- **Co-Creation and Globalism:** What are the current challenges concerning Global design, multicultural design, translational design, cooperative design, especially perhaps in the China context.
- **Social Computing and the Nature of Dynamic STUFF:** How might Designers respond to; and what are the key changes and challenges we see in the role of design, the nature of systems design, service design and social design; especially when considering the

potentially pivotal effects of computational networks on Social Cohesion in the Global contexts (i.e. Social Computing)

DeSForM is about Design and Semantics of Form and Movement. The making of meaning through 'matter' is of increasing relevance to the practice of design in the twenty-first century. Rapidly evolving techniques and processes are creating pathways for new modes of interactivity, expression, and experience. These modalities offer expanded opportunities and contexts for design to communicate meaning through form, movement and experience.

Since the first DeSForM conference, the field of design has been changing a lot, but not as much as it should have, to respond to significant societal changes. One important external change is the development and widespread application of social computing. Social media fundamentally change the relationships between people and it changes their behavior. This is significant for design and at DeSForM 2013 we ask: how should design respond. Any innovative system, service, or related product is a combination of material concepts and digital concept. Material form-giving and digital form-giving. Which are the new tools that the design research community will offer to cope with this new complexity?

Another change is continued globalization. The countries and the peoples of this planet are becoming more and more connected, through travel, migration, trade, the Internet, and new media. Communication and exchange between cultures is an essential ingredient of design. Already since the beginnings of Industrial Design, the designed objects have been considered culturally important. Nowadays we understand that the output of our design work has the power to change the behavior of people. DeSForM always has been trying to pave the way for objects displaying active behavior. We have to ask: what are the best state-of-the-art examples where design is mediating between cultures, countries, and people. And the new tools that help us when designing in a multicultural setting?

And still some of the core-questions of DeSForM have been answered only partially so far. These are the questions about our fundamental understanding of meaning and movement. How does meaning arise? Can

we assign meaning to the movement of artifacts and our interactions with them without relying on the meaning of their three-dimensional form? These questions are becoming urgent now meanings are modulated and amplified by the Internet, smart phones and social media. We should also be prepared for new actuators: smart polymers, memory metals, scent and light as media. What will our design process look like when the constraints of the traditional form are disappearing?

This year's DeSForM conference tries to address these questions from different perspectives by authors from the Netherlands, Italy, Czech, Denmark, Turkey, United Kingdom, United States, New Zealand and China, covering wide range of topics in 15 long papers and by 11 interactive demos, which are selected from 42 submissions.

We are also honored to have five renowned keynote speakers (3 from Europe, and 2 from China) joining us to address these questions for the conference:  
**Prof. Chris Dorsett** from Department of Arts, School of Arts, Design and Social Sciences, Northumbria University to share with us his interests in the semiotics of paper, in which he explores the diverse forms of graphic innovation required to realize symbolic 'value' transactions on paper.

**Prof. David Frohlich**, director of Digital World Research Centre at the University of Surrey and Professor of Interaction Design. In his talk, he will examine the relationship between products and media, especially in the early stages of product design when their properties are fluid and functionalities are still being defined.

**Dr. Stephan Wensveen**, associate professor Interaction Design at the Mads Clausen Institute, University of Southern Denmark. He will talk about 'Constructive Design Research'. Multiple examples will illustrate this type of design research that highly values imagining and building new things while describing and explaining these constructions.

**Prof. Xiaoyou He**, vice president of Nanjing University of Arts. He will share with us how we could introduce Chinese traditional culture to modern design and focus on research on the 'fusion state' of people, product and

environment. It will emphasize not on the interactive relations between people and product, but on the 'fusion state' of people and creations.

**Prof. Xiangyang Xin**, dean of the School of Design, Jiannan University. He will tell us that it is important to recognize the role of intention in the realization and utilization of the things. His lecture will look for sources of intention, and searches for preliminary strategies for identifying attributes and functions of intention, not just in the creation but also the utilizations of man-made objects.

This year's DeSForM is also preceded by a seminar "Design for Research", in which the experts will share their observations and experiences how design can contribute to research, and discuss how designers in the academia can meet their design background with the academic challenges.

**Prof. Loe Feijs** will raise questions around product semantics and share his knowledge about the structure of product semantics and how they can effectively communicate and help users to effectively communicate.

**Dagmar Steffen** will argue that the interplay of design practice and design theory as it takes place in practice-led design research creates a mindset that is beneficial for the discipline in general and especially for design education since it contributes to bridging the gap between unconsidered design practice on the one hand and abstract design theory, bereft of any relevance for practice on the other.

**Dr. Edgar Rodriguez** will discuss how the practice of design produces knowledge, why academia expects research to produce explicit knowledge and how practicing designers can engage in academic research without compromising the quality of their practice.

**Prof. Steven Kyffin** will introduce some of Northumbria University's Design Research work in the context of the paradox of Practice and Scholarship and discuss some of the challenges facing Design Academics as they develop their 'design' careers in Academia.

**Dr. Tom Djajadiningrat** will share with us his experience at Philips Design where research has its culture, showing us that there are different levels of

decision support in a design process, from merely offering information which helps informed decisions, via guidance which nudges the user towards particular behavior or choices, up to pro-active identification and correction of poor decisions.

**Dr. Christoph Bartneck** will talk about academic publications for designers. In his opinion, the academic publication process has some fundamental laws that inhibit the publication of innovative ideas. He will reflect on some of the underlying problems of putting design work into the scientific context and will present insights into how we can overcome some of the issues of the academic publication process.

Alongside this year's DeSForM conference, for the first time, we will also organize a design competition. Five student teams from top Chinese design schools are invited to the competition in the area of designing for public spaces using digital augmentation to physical spaces or objects. All the teams are provided with earlier technology support over distance and 1:1 scale models of buildings or statues will be revealed on the first day of the conference and the challenge is to augment these models with digital media and with meaningful interactions. The experts from the DeSForM conference will provide guidance throughout the competition – we hope that the knowledge from the DeSForM conference will have a direct influence on the young designers, and contribute to their growth and development. The winning team will also get an award – eight tickets to the next DeSForM conference, to promote the DeSForM conference among the young designers.

The conference can only take place in this form thanks to the excellent local administrative and financial support from the School of Digital Media, Jiangnan University. We would also like to thank the sponsorship of Philips Design, and the TU/e DESIS Lab and the Out of Control theme of the Department of Industrial Design, Eindhoven University of Technology. Thanks to the Wuxi Museum of Chinese Calligraphy and Paintings, the conference can be held at a place with a rich culture and history, in a beautiful nature. The IFIP WG14.7 workgroup in Art and Entertainment, the DESIS network and the Cumulus Association endorsed the conference by spreading the CFP to their members.

Special thanks to our local organizers and the supporting team, not mentioning them all, especially our local co-chair prof.dr. Feng Wang, and our conference secretary ms. Tiantian Yang and ms. Xingwei Wang, for taking care of the details with a great amount of effort and patience.

We hereby offer the 8th DeSForM Proceedings. We would like to thank all the authors who have submitted their work to DeSForM 2013 as well as the reviewers for their constructive and critical comments. We hope the presentations and demonstrations will raise many questions and inspire lively discussion and debate about the increasing sophistication and complexity of design research, theory and practice in a constantly changing global context.

*Wuxi, August 18, 2013*

**Lin-Lin Chen,**  
National Taiwan University of Science and Technology,  
Taiwan

–

**Tom Djajadiningrat,**  
Philips Design Eindhoven, The Netherlands

–

**Loe Feijs,**  
Eindhoven University of Technology, The Netherlands

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**Simon Fraser,**  
Victoria University of Wellington, New Zealand

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**Jun Hu,**  
Eindhoven University of Technology, The Netherlands

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**Steven Kyffin,**  
University of Northumbria, Newcastle Upon Tyne,  
United Kingdom

–

**Dagmar Steffen,**  
Lucerne University of Applied Sciences and Arts,  
Switzerland

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## Programme DeSForM 2013

### September 22

- 10.00 – 19.00 Conference Registration  
13.00 – 18.00 Seminar 'Design For Research'  
19.00 Reception dinner

### September 23

- 09.30 – 10.00 Opening speeches  
10.00 – 11.00 Keynote 1  
David Frohlich  
*Framing the design of new media experiences*  
11.00 – 11.30 Opening (design competition)  
12.00 Lunch  
14.00 – 15.00 Keynote 2  
Chris Dorsett  
*At a moment's notice, according to the pleasure of the holder. the semiotics of paper*  
15.00 – 15.30 Tea  
15.30 – 17.00 Paper session 1: Meaning and semantics  
Alan Young  
*The Value of a 'Semiotic Sensibility' in Graphic and Communication Design*  
Ozge Merzali Celikoglu  
*Three dimensions of lace: Reading the meaning of a traditional product from different perspectives*  
Ehsan Baha, Dirk Snelders, Yuan Lu and Aarnout Brombacher  
*Retracing an Evolution of Meanings for Design-Driven Innovation*  
19.00 Dinner

### September 24

- 09.00 – 10.00 Keynote 3  
Stephan Wensveen  
*Design Research through Practice. From the Lab, Field, and Showroom*  
10.00 – 11.00 Tea / Demos  
11.00 – 12.30 Paper session 2: Design, exploration and frameworks  
Evelien Van de Garde-Perik, Federico Trevia, Adam Henriksson, Luc Geurts and Helle Ullerup  
*Getting a GRIP at the Design of a Nature Inspired Relaxation Space for Work-Related Stress*  
Christoph Bartneck  
*Robots in the Theatre and The Media*  
Sara Colombo and Lucia Rampino  
*Beyond Screens. Exploring product dynamic features as communication means*  
12.30 – 14.00 Lunch  
14.00 – 15.00 Keynote 4  
Xiaoyou He  
*'Interaction' & 'Fusion'*  
15.00 – 16.00 Tea / Demos

16.00 – 17.30 Paper session 3: Big data and social design  
 Heather Renée Barker  
*Hive-Design for Big Data*  
 Colin Kennedy  
*Designing to Scale: Social Relations Design*  
 Sophie Brenny and Jun Hu  
*Social Connectedness and Inclusion by Digital Augmentation in Public Spaces*  
 19.00 Dinner

### September 25

09.00 – 10.00 Keynote 5  
 Xiangyang Xin  
*Intention, not just in the minds of Designer*  
 10.00 – 11.00 Tea / Demos  
 11.00 – 12.30 Paper session 4: Interaction and experience  
 Loe Feijs  
*Multi-tasking and Arduino. Why and How?*  
 Gustavo Ostos Rios, Mathias Funk, Bart Hengeveld and Joep Frens  
*EMjam: Jam with your Emotions*  
 Christopher Henley, Yaakov Lyubetsky, Ajay Ravindran, Canute Haroldson, Mark Baskinger  
*Project Loci: Haptic Interactions Influence Situational Awareness*  
 12.30 – 14.00 Lunch  
 14.00 – 15.30 Paper session 5: Healthcare  
 Edgar Rodríguez Ramírez and Kah Chan  
*Smart interactions for home healthcare: A semantic shift*  
 Jing Gu, Yu Zhang and Jun Hu  
*Design for Elderly with Dementia: Light, Sound and Movement*  
 Dominika Potuzakova and Loe Feijs  
*Oris: Bonding through maternal scent*  
 15.30 – 16.00 Tea  
 16.00 – 17.00 Presentations (Design Competition)  
 17.00 – 17.30 Closing speeches  
 19.00 Closing Dinner

### September 26

Cultural events

### prof. Chris Dorsett

Professor of Fine Art, Department of Arts, School of Arts, Design and Social Sciences,  
Northumbria University (UK)

## At a moment's notice, according to the pleasure of the holder: the semiotics of paper

For contemporary graphic artists the detachment of the ocular-centric 'virtual' from the sensory pleasures of the hand is accepted as a necessary consequence of moving one's attention from a computer screen to a printed page. In the Art and Design sector we continue to celebrate well-made products but enthusiastically embrace the creative restlessness of ongoing deferral made possible by electronic 'information', an enthusiasm that encourages us to write many more emails than we would letters and build a series of websites when, in the past, we would have curated a single exhibition. As a creative practitioner whose research is realised primarily through drawing and photography I wrestle with the potentiality of blank sheets of paper on a day-to-day basis and it is the redefinition of this experience in relation to the indeterminateness of digital technology that will serve as the topic of my presentation.

My title quotes the British political economist David Ricardo (1772 – 1823) who argued that the introduction of paper money in late 18th century Britain would lead to uncontrollable fluctuations in the value of currency unless the scope to convert each 'note' into metal was, for the bearer of these new fangled sheets of printed paper, executed on demand – that is, 'at a moment's notice, according to the pleasure of the holder' (Barry, 2007: 68). It is difficult not to see parallels to our current situation. For Ricardo, paper money severed the representational force of a signifier from the intrinsic value of that which was signified and this same semiotic rupture, I suggest, shapes the virtual and artefactual tensions of today (see, for example, Rawsthorn 2013)

However, the literary historian Kevin Barry (1997, 2007) has linked the deferred 'promise to pay' of the first paper pounds to the open-ended character of the 18th century creative imagination and my presentation will explore this same symbiosis of monetary and aesthetic exchange in our own period of economic fluctuation. I will also offer scope for creative reflection on curatorial treatments of printed currency at Princeton University Library (Stahl, 2010) and the coin and banknote displays at Oxford University's Pitt Rivers Museum. This latter collection represents numismatic problem-solving and innovation in the widest geographic and historical contexts offering, it is my contention, endless opportunities to model the restlessness of the creative imagination in general.

And so: do Ming Dynasty circulating treasure notes raise important questions about graphic images on a computer screen? My answer will be yes, and these questions help us set out parameters for a contemporary semiotics of paper in which, following debates about touch-based experiences in David Howes' *Empire of Senses* (2005) and my own *Things and Theories: the unstable presence of exhibited objects* (2011), the 'pleasure of the holder' must play a significant role.

Barry, K. (2007) 'The Aesthetics of Paper Money: national differences during the period of enlightenment and romanticism', in Duff, D. & Jones C. (eds) *Scotland, Ireland and the Romantic Aesthetic*, Lewisburg, PA: Bucknell, pp.55-76.

Paper Money and English Romanticism, *Times Literary Supplement*, No. 4899, 21 February 1997: 14-16.

Dorsett, C. (2011) 'Things and Theories: the unstable presence of exhibited objects'. In Dudley, S., Barnes, A. J., Binnie, J., Petrov, J., & Walklate, J. (eds) *The Thing about Museums: Objects and Experience, Representation and Contestation*, London and New York: Routledge.

Howes, D (2005) *Empire of the Senses*. Oxford: Berg

Rawsthorn, A. (2013) *Hello World: where design meets life*, London: Hamish Hamilton.

Stahl, A. (curator) (2010) *Money on Paper: Bank Notes and Related Graphic Arts from the Collections of Vsevolod Onyshkevych and Princeton University*, Leonard Milberg Gallery for the Graphic Arts, Firestone Library, Princeton University.



► Chris Dorsett is an artist and exhibition curator whose career has been built on cross-disciplinary collaborations with collection-holding institutions such as the Pitt Rivers Museum in Oxford and the Royal Swedish Armoury, Stockholm. His curatorial activities also include fieldwork residencies in the Amazon (organised with the Centre for Economic Botany, Kew) and the walled village of Kat Hing Wai (commissioned by the Arts Development Council of Hong Kong). Dorsett seeks to resituate the changing aesthetic and political ambitions of the visual arts within the widest range of historical and scientific contexts and, as a Professor of Fine Art at Northumbria University, he continues to interrogate museological claims about the construction of knowledge through exhibition display. He publishes with Routledge for the museums studies sector and was recently commissioned to lead *Cast Contemporaries*, an exhibition about the fate of anatomical and sculpture cast collections in art schools (2012 Edinburgh Arts Festival).

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## Keynotes

### prof. David Frohlich

Director Digital World Research Centre  
University of Surrey

## Framing the design of new media experiences

Many modern products and services involve the presentation of digital media content of various kinds. Sometimes this content defines the form and function of the product, as with televisions, music players or e-books. In other cases the relationship is less clear, as with smart phones or computers, which are really conduits for multiple types of media and experiences.

In this talk, I examine the relationship between products and media, especially in the early stages of product design when their properties are fluid and functionalities are still being defined. I argue for attention to five key factors which frame the design of new media experiences, and shape their character and meaning. These include Form, Reason, Audience, Material and Extent (FRAME). To illustrate this framework, I show how the factors interact in the design of three digital photography systems originating from both corporate and university research labs. These include an interactive desk for playing the sound of printed photographs, a live digital storytelling system, and a kind of visual twitter display. In each case, it is possible to see how small changes in framing shift the resulting design and experience, and how the trick of good design is to find an alignment of factors that 'works' for users. The complexity of interactions between factors often leads to surprises in the behavior of such systems, and suggests an open-minded exploratory approach to their design.



▶ David Frohlich is Director of Digital World Research Centre at the University of Surrey and Professor of Interaction Design. He joined the Centre in January 2005 to establish a new research agenda on user-centred innovation in digital media technology. Current work includes a mixture of PhD and Research Council projects exploring a variety of new media futures relating to digital storytelling, personal media collections, and community news and arts (<http://www.dwrc.surrey.ac.uk/>). His recent 2012 book with Risto Sarvas contains the first history of personal digital photography: From snapshots to social media: The changing picture of domestic photography. Prior to joining Digital World, David worked for 14 years as a senior research scientist at HP Labs, conducting user studies to identify requirements and test new concepts for mobile, domestic and photographic products. This allowed him to pursue ongoing research interests in tangible interfaces to computing, new media design, and the global digital divide. Some of this work was documented in two books entitled *Audiophotography: Bringing photos to life with sounds*, and *Contextual Innovation: Creative approaches to innovation in emerging markets*.

David has a PhD in psychology from the University of Sheffield and post-doctoral training in Conversation Analysis from the University of York. He has also worked as a Human Factors Consultant and Research Psychologist, and held visiting positions at the Helen Hamlyn Research Centre, Royal College of Art, and the Department of Psychology, University of York. He is currently Visiting Professor at Manchester Business School and is founding editor of the international journal *Personal and Ubiquitous Computing*.

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## Keynotes

### dr. Stephan Wensveen

Associate Professor  
University of Southern Denmark

## Design Research through Practice. From the Lab, Field, and Showrooms

This presentation talks about 'Constructive Design Research' as brought forward in the co-authored book 'Design Research Through Practice. From the Lab, Field, and Showroom' (Koskinen, Zimmerman, Binder, Redström and Wensveen, 2011). Multiple examples will illustrate this type of design research that highly values imagining and building new things while describing and explaining these constructions. The basis for the book and the presentation are three observations:

- **Methods in design research proliferate, but there are three main methodological approaches: Lab, Field and Showroom.**
- **These approaches share a theoretical and philosophical basis that sets them apart from earlier attempts to turn design into a science.**
- **Design is not only the object of research, but the very means of doing it.**

This last observation will be deepened by focusing on the roles that prototypes and the act of prototyping can play in design research. In this presentation we will celebrate the diversity of how designing can generate knowledge in design research.



▶ Stephan Wensveen (1970) is Associate Professor Interaction Design (since 2011) at the Mads Clausen Institute, University of Southern Denmark. He studied, educated and researched Industrial Design Engineering at Delft University of Technology. His research on the relationship between emotions, expressivity and product design started in 1999 and resulted in a PhD thesis, which is seen by the design research community as a canonical example of Research through Design. The main contributions were a validated prototype of an 'emotionally intelligent alarm clock' and a theoretical framework for interaction called 'Interaction Frogger'. He has enjoyed to be part of, and be of influence on internationally renowned design research groups, i.e., the Delft ID-StudioLab (lead by Kees Overbeeke, Pieter Jan Stappers, Paul Hekkert & David Keyson), the Eindhoven Designed Intelligence and Designing Quality in Interaction group (lead by Loe Feijs, Kees Overbeeke and Caroline Hummels) and the Sønderborg Participatory Innovation Research centre (lead by Jacob Buur).

His interest is in using the power of design to integrate research, education and innovation, which he demonstrated as project leader for the /d.search-labs and as initiator and research director of Wearable Senses and the Dutch nationally funded project on Smart Textile Services. He has any of his papers are part of the standard curricula in interaction design schools and he is co-author of the book 'Design Research through Practice'. In 2011 he expanded his horizon on multi-disciplinary design, when he joined the Sønderborg Participatory Innovation Research group of Prof. Jacob Buur at MCI to focus on the Aesthetics of Participation.

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## Keynotes

### prof.dr. Xiaoyou He

Vice President of Nanjing University of Arts,  
PHD Supervisor

## 'Interaction' & 'Fusion'

Since Bill Moggridge of IDEO formally proposed the concept of "interaction design" in 1990, it has become a hot topic in design thinking and methods.

Interaction design seems to be an alternative concept to 'product design'. Traditionally, product design concerns the function, structure, human factors, form and styling, color, environmental effect and other design elements such as technology, methods and means of achieving other functions. While interaction design emphasized on the interactive behaviors between product system and end-users, on the technical support to realize the defined functions and emotional communication between both interactive sides. These are believed to have the direct impact on the end users.

We have no doubt on the development of this concept as well as the changes it has caused. In the meanwhile, we would like to ask is this the most reasonable design idea?

Interaction design, is still emphasized on the interaction between 'this' and 'that'. According to this, it is the interaction of two individuals. If we can change another way to think, if the problem we are going to solve is not the problem between 'product' and 'people', it is the problem of 'people themselves', what it is now?

If we trace back to Chinese traditional wisdom of creation, there are a lot of ideas worthy of research on design thinking and methods.

- Chinese traditional thought of the theory that 'man is an integral part of nature'
- Chinese traditional philosophy of 'Yin Yang complementarity'
- Chinese traditional artifact of 'two is made of one'
- Chinese traditional human relations of 'a man of kindness is benevolent people'

In Chinese traditional culture, 'you are among us and we are among you' is much more recommended than 'you and he'. This describes a 'fusion' state which is believed to inherit the spirit of 'symbiotic harmony'.

By introducing Chinese traditional culture to modern design, we can focus on research on the 'fusion state' of people, product and environment. It will emphasize not on the interactive relations between people and product, but on the 'fusion state' of people and creations. All in all, it is not to design an object, but to design 'people' in order to create a fusion state of 'great coordination'.



- ▶ Deputy Director of Committee of Design Education, Ministry of Higher Education
- Research Fellow of China Institute of Chinese Art
- Research Fellow at Public Art in China National Art Academy
- Director of Committee of Design Research, China Industrial Design Association
- Deputy Director of Committee of Art & Design, China Association of Higher Education
- Member of Industrial Design Art, China Artists' Association
- Vice President of Association of Industrial Design in Jiangsu Province

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## Keynotes

**prof.dr. Xiangyang Xin**

Dean, School of Design, Jiangnan University, China

# Intention, not just in the minds of Designers

While designers are expected to create future scenarios of people's lives through objects, services and/or systems, it is important to recognize the role of intention in the realization and utilization of the things. Often people think that intentions locate in the minds of designers, and lead to the choices of problems to be addressed, things to be made and details that ensure things to be appreciated. It is true that designers' intention play important roles in the creation of our material environment. What is not understood is that intentions are not independent things live the minds of designers, but outcomes of complex social interactions.

This lecture looks for sources intention, and searches for preliminary strategies for identifying attributes and functions of intention, not just in the creation but also the utilizations of man-made objects. Instead of providing developed understanding of intention, here the goal is to promote interests and conversations of issues surrounding intention.



► Xin holds a PhD in Design from Carnegie Mellon University with research interests in interaction and service design, cultural studies, and product development. He looks at how design, both professionally and philosophically, contributes to transformations of lifestyles, businesses and societies. Xin is currently leading a "Redesign Design Education" movement in China. It aims to reform design education responding to the extending scope and evolving principles of design, from "logic of things to logic of behaviors." Xin has internationally spoken and conducted workshops on interaction design and cultural innovation, served as a guest professor at different universities, actively served for several professional communities including CIDA, IDSA, IXDC, IXDA. His professional practices covers a variety of industries with partners including United States Postal Services, Efficiency Unit of Hong Kong Government, P&G, Changhong, ASTRI (Applied Science and Technology Research Institute Ltd., Hong Kong), Philips and etc.

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## Seminar: Design for Research

**prof. Steven Kyffin**

Dean of the Faculty of Arts, Design and Social Sciences,  
Northumbria University

# Design research in the academic context: practice vs scholarship

Many of us have experienced that the notion of Design Research has often been the cause of much conflict, creative conflict, in both the Academic and the Commercial contexts alike. Design is a Research activity in itself. So, what does Design Research mean to us in Academia and in the 21st Century?

How do we understand these concepts, how do we make sense of them and how do we contribute to Transforming our futures; the future of our people, the future of our world and the future of our Discipline while at the same time, being and acting as a Designer?

Ever since I joined the Royal College of Art in 1981 I have experienced something of the paradox, which the notion of 'Research' proposes: one the one hand an activity, which seeks to UNDERSTAND the world more fully through Objective Scientific Objective Experimentation in Laboratory contexts, while on the other hand the other strives to CHANGE the world through often Subjective, Exploration in Community contexts. At a dangerously simplistic level, one appears to be an act of Creation through Practice and the other an act of Scholarship through Study, and yet somehow we can bring them together. Both the Analytical and the Synthetical approaches do of course come together. Of course as I believe that we are all Creative and as such have a desire to create a 'better' world for the future. But none the less the two approaches do set up a tension in the academic contexts, which in time I believe can become a 'most creative' one from which we can all grow!

This is something that I'd like to discuss during this seminar while at the same time sharing some examples of the work we create as part of our Design Research Programmes at Northumbria University.



► Professor Steven Kyffin (Master of Design, Industrial Design, Royal College of Art, London & Honorary Doctorate Northumbria, Newcastle) is Executive Dean of the Faculty of Arts, Design and Social Sciences at Northumbria University, Newcastle in the United Kingdom.

In this function he is responsible for all aspects of the management of the Faculty, one of four in the University. From 2010 until 2012, Steven was Dean of the School of Design within Northumbria. Northumbria Design focuses its teaching programs on Fashion, Communication, Industrial and innovation Design across its Undergraduate and postgraduate programs. Design Innovation is one of the three core Research territories of the school. The others include; The future Roles of Design in Socio-Economic contexts and Design Futures; a Design led exploration of future qualities on Life in the Health and Wellbeing and Digital Life contexts.

Kyffin's own Research has focused on multi and trans disciplinary Innovation in general and in particular on the roles, which Experience Design and prototyping can play in leading the Business and Social Innovation processes.

Steven previously held the post of Senior Global Director of Design Research and Innovation at Philips Design in the Netherlands. He was responsible for Design Research for Philips Electronics world-wide.

As a member of the Philips Design Global Management Team, Steven headed up Philips Design's European Commission Research Relations Programme and led the Philips Design University Relations Programme.

Steven Kyffin is a member of Northumbria University's Executive Management Team, acts as a European Commission research program reviewer and holds Adjunct Professorships in the schools of Design at Hong Kong Polytechnic University and at Jiangnan University, Wuxi, China.

prof.dr.ir Loe Feijs

Department of Industrial Design,  
Eindhoven University of Technology, The Netherlands



## Product semantics: Quo Vadis

Product semantics is a central theme in the field of Industrial Design. Forms, either abstract or concrete always carry meanings. It is the responsibility of designers to make good use of the possibilities of these meanings. 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 and help users to effectively communicate. In this presentation I will review a number of classical theories about product semantics – mostly Western theories. These include the notions coming from semiotics, such as the work of Charles Peirce and Umberto Eco. We shall go back the classic sender-receiver model of Claude Shannon, next to achievements of the Offenbach school of product semantics and compare these with the more recent semantic turn by Klaus Krippendorff. In engineering traditions such as computer science, formalization has always been a first step towards making more powerful tools and in this context my own Commutative Product Semantics (CPS) will be explained. Then I will introduce the terminology of closed and open semantics. Whereas closed semantics is based on Peirce's and Shannon's classic ideas, open semantics is about designs which work as a medium, a carrier, or a tool. Open semantics allows the user to put his or her own meanings into the design and connect these to new rituals. Product semantics becomes a participatory process. When talking about media, the theories of McLuhan are helpful too. I shall argue that open and closed semantics both play an essential role, usually even within a single design. All concepts will be illustrated by classic and contemporary examples. The last part of the presentation will be about the future of product semantics. Questions addressed include: **What is the impact of Social Computing upon the field of product semantics? Why do most of our design tools not have any semantic knowledge embedded? Can we deploy Semantic Web technologies to advance the field of product semantics?**

► Loe Feijs (The Netherlands, 1954) is professor of Industrial Design at Eindhoven University of Technology. He holds a Master's degree in Electrical Engineering and a Doctor degree in computer science. He has worked on formal methods in Philips Research Laboratories, he was director of the Eindhoven Embedded Systems Institute and Vice dean of TU/e ID. At present he holds the chair Industrial Design of Embedded Systems. He teaches topics such as Integrating Technology and Creative Programming. His research interests include creative programming, product semantics, design for neonatology, medical simulation and biofeedback.

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## Seminar: Design for Research

### Dagmar Steffen

Lucerne University of Applied Sciences and Arts, School of Art and Design (Switzerland)

## The interplay of design practice and design research

The relationship of scientific research in the field of design and design practice was and still is under debate. For many decades, both activities were strictly separated, but during the last two decades an increasing number of universities of art & design around the world introduced so-called practice-led design research or “research through design”. In my talk I will focus on three issues. Firstly, I will argue, that the inclusion of material practice (“doing & making”) in scientific research is not specific to design; indeed, in various disciplines material practice has a long tradition (i.e. medicine, physics and archaeology) and inevitably contributes to knowledge creation. Nonetheless the role or function of practice in practice-led design research (including doctoral research) demands closer examination and justification. Thus, secondly I will elaborate the commonalities of and the differences between material practice resp. the role of the artefact in research in the before mentioned disciplines and in design research (the design object: as an experimental, hypotheses-testing or explorative artefact; as a non-discursive symbolism; as a work in its own right). Finally I will argue, that the interplay of design practice and design theory as it takes place in practice-led design research creates a mindset that is beneficial for the discipline in general and especially for design education since it contributes to bridging the gap between unconsidered design practice on the one hand and abstract design theory, bereft of any relevance for practice on the other.



▶ Dagmar Steffen is a researcher and lecturer at the Lucerne University of Applied Sciences and Arts, School of Art and Design (Switzerland). She works primarily in the areas of product semantics, design and innovation and design and sustainability. She studied Product Design at the Academy of Art and Design Offenbach (Germany) and at the Edinburgh College of Art (UK). From 2000-2003 she has been a member of the research staff at the Academy of Art and Design Offenbach; from 2004-2007 she was a visiting lecturer at the Bergische University Wuppertal (Germany), while joining part-time the SeFun (Semantic Functions in Design) research project at the Aalto University School of Art and Design (Finland). She is author of numerous publications (books, articles and conference papers) and holds a PhD.

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## Seminar: Design for Research

**Dr Edgar Rodriguez**

Victoria University of Wellington

# How practicing designers can engage in academic research

With the move in many countries to assess academics according to their research performance in measurable ways, many design practitioners moving to academia have faced the challenge of justifying their practice as research. This has had several outcomes. Firstly, some highly skilled designers receive low assessments as their practice is not considered research, which in turn discourages them to work in academia and it also discourages academic institutions to hire them. Secondly, some highly skilled designers reframe their activities and produce other kinds of academic research outputs (i.e. journal articles) to the detriment of their practice. Thirdly and most challenging, some highly skilled designers frame their practice around well-defined research questions that can only be answered through the practice of design. Their outputs are sophisticated designs that add new tacit and explicit knowledge to the discipline. These designers need research and practice skills that, while unusually taught together, can benefit the academic and practice areas of the discipline and bring them together to fill a gap that shouldn't exist.

Through examples of design and research work, this seminar will discuss how the practice of design produces knowledge, why academia expects research to produce explicit knowledge and how practicing designers can engage in academic research without compromising the quality of their practice.



► Dr Edgar Rodriguez is the Programme Director in Industrial Design at the School of Design, Victoria University of Wellington, New Zealand. His career as industrial designer includes working for design studios Sismo Design (Paris), MDA (Mexico City), Studio Santachiara (Milan) and Samsung Electronics (Seoul). He has produced designs that include furniture, lighting, digital cameras, TV sets, wearable computers, medical devices and experimental designs. He has exhibited and published his research in dozens of international conferences and exhibitions. His current research studies how human data including physiological responses, behaviour and emotions can be studied to design smart interactions that help people improve their lives.

### Tom Djajadiningrat

Creative director innovation design at Philips Design

## Meddling or helpful? The Semantics of Decision Support UIs

The spiralling costs of healthcare are creating a need for medical products and systems which can be used by less trained staff or even by patients themselves. At Philips Design, this has led to an increased interest in 'clinical decision support' (CDS). The common understanding of CDS systems is that they assist physicians and other health professionals with decision making tasks, such as making a diagnosis based on patient data. However, we are interested in applying the concept of CDS not only to diagnostics for healthcare professionals but also to consumers struggling to make healthy choices.

An often neglected aspect is how user interfaces can offer CDS to the user. Through an analysis of many decision support UI examples from fields other than healthcare, I would like to show that there are different levels of decision support, from merely offering information which helps informed decisions, via guidance which nudges the user towards particular behaviour or choices, upto pro-active identification and correction of poor decisions. The semantics of the design execution of such CDS UIs largely determine whether CDS is experienced as meddling and misinformed or quietly helpful and intelligent.



► Tom Djajadiningrat is creative director innovation design at Philips Design. In his role as leading co-creator in a team of complementary disciplines, his focus is on helping Philips re-position itself as a Health & Well-being company. Prior to joining Philips, he worked in academia at the ID-StudioLab of Delft University of Technology, The Mads Clausen Institute of the University of Southern Denmark and the Design IntelligenceGroup of Eindhoven University of Technology.

**Dr. Christoph Bartneck**  
HIT Lab NZ of the University of Canterbury

## Academic Publications For Designers

The number of published papers is one of the main key performance indicators for academics. Designers working at a university have to live up to this expectation, but struggle with translating their research output into disseminations that are being recognized by colleagues from different disciplines. To make things worse, it has been shown that the academic publication process has some fundamental flaws that inhibit the publication of innovative ideas. I will reflect on some of the underlying problems of putting design work into the scientific context and will present insights into how we can overcome some of the issues of the academic publication process.



▶ Dr. Christoph Bartneck is an associate professor and director of postgraduate studies at the HIT Lab NZ of the University of Canterbury. He has a background in Industrial Design and Human-Computer Interaction, and his projects and studies have been published in leading journals, newspapers, and conferences. His interests lie in the fields of Social Robotics, Design Science, and Multimedia Applications. He has worked for several international organizations including the Technology Centre of Hannover (Germany), LEGO (Denmark), Eagle River Interactive (USA), Philips Research (Netherlands), ATR (Japan), Nara Institute of Science and Technology (Japan), and The Eindhoven University of Technology (Netherlands). Christoph is a member of the New Zealand Institute for Language Brain & Behavior, the IFIP Work Group 14.2 and ACM SIGCHI.

# The Value of a 'Semiotic Sensibility' in Graphic and Communication Design

## **Abstract**

At a time when multiplicities of forms, media, technologies and pedagogical approaches abound, this paper argues for semiotics as a unifying theoretical foundation for the range of communication design practices. This is not to say that semiotics should be the only approach to design education—far from it. I argue that other approaches, including that of connoisseurship have much to offer design students, but that without semiotics, they stand to do as much harm as good. The only viable approach to design education is one that is holistic, and responsive to ever changing global and local conditions and requirements. As a way of making visible the often latent, yet potentially communicative aspects of all design artifacts, semiotics offers a firm foundation through which all other pedagogical approaches can benefit and from which the meaning of design artifacts and production can be understood. Semiotics enables one to explore, analyse, and greatly enhance the creation of works not only in graphic design, photography, and advertising, but also sound production, product design, and any other system where artifacts communicate to an audience or market. Although this paper concentrates on graphic and communication design, its reasoning can be applied equally to these other areas. Although some might suggest semiotics had its hay day in the 1970s and 1980s and is now on the decline, I would argue it has never reached its full potential in design discourse and there

is now, more than ever, the need for a reappraisal of the value of semiotics in design pedagogy.

## **Keywords**

Semiotics, design process, graphic design, communication design, design history, social innovation, social justice

## **1 Introduction**

Semiotics is the study of signs and their relation to culture. Originally proposed by Ferdinand de Saussure in his Course in General Linguistics, he saw it as a science that would show “what constitutes signs, what laws govern them”, but importantly, “that studies the life of signs within society” [1]. Out of philosophy rather than linguistics, Charles Sanders Peirce developed a more relational model of the sign with the additional consideration: “It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign” [2]. The connection of signs and culture was developed by a number of theorists, of whom perhaps the most significant for designers is Roland Barthes, who defines the study thus:

*Semiology aims to take in any system of signs, whatever their substance and limits; images, gestures, musical sounds, objects, and the complex associations of all of these, which form the content of ritual, convention or public entertainment: these constitute, if not languages, at least systems of signification. [3]*

What Barthes is referring to include key aspects of graphic design and it might therefore seem surprising that semiotics, whilst appearing as a component part of many graphic design courses, has not featured more significantly within the discourse. Kress and van Leeuwen [4] make the observation that:

*Within the media, visual design is still the province of specialists who generally see little need for methodical and analytically explicit approaches, and rely on creative sensibilities honed through experience (p. 12).*

Storkerson [5] notes of semiotics in graphic design education “its apparent lack of broad visibility”, which he attributes to antinomies or contradictions, due largely to incompatibilities in the key semiotic approaches of Peirce and de Saussure, as well as a range of other difficulties, namely: “defects in the theories, difficulty in understanding them or their obscure terminology, difficulty in applying them, or... that graphic designers are averse to semiotic theories or theories in general” (p. 7). Whilst Kress and van Leeuwen and Storkerson make valid points, and there are certainly differing viewpoints of how semiotics should be theorized (see, for example, Krippendorff [6]), I suggest the more powerful antinomies are those not within the theories of semiotics, but within the historical emergence of the discourses of design and graphic design. The first half of this paper describes this historical emergence to show how it militates against any significant incorporation of semiotics, whilst the second half is a response to specific arguments against semiotic approaches in design discourse.

I use the term discourse in the Foucauldian sense [7], whereby certain practices are brought together as a unity. Through this process, previously disparate components of the discourse are linked and officially sanctified through a professional language with concurrent systems of accreditation which specify what may be practiced and who may practice it. An important part of the process of gathering together these disparate practices is the defining of various sub-categories such as graphic design, industrial design, interior design and the like. In graphic design, the traditional practices of aesthetic construction of type elements on a page and the ‘laying out’ of images and type together, as well as many other traditional

and modern practices, are drawn together under the ‘graphic design’ banner, whilst other previously related practices, such as much of the preparation work for printed media are excluded. Precisely what is chosen to be included and what remains excluded from the category ‘graphic design’ and thus what is and is not to be considered within the boundaries of design discourse are seen here in terms of the historical power struggles of various social and institutional groups.

## 2 The Emergence Of Graphic Design Discourse

I have argued previously [8] that graphic design emerged, as does any discourse, out of a confluence of numerous events, approaches and conditions. Social, economic and political changes occurred in the printing and advertising industries in the Twentieth Century, which allowed for the emergence of graphic design. This new discourse subsumed much of the creative practices hitherto the purvey of printers, but with the addition of qualities, aspects of historical trajectory, values and language of fine arts discourse. There had been for some time an uneasy relationship between fine and commercial arts, where commercial arts was seen as somewhat of a poor cousin, and in some senses, even the antithesis of the ‘disinterestedness’ of fine art. The emergence of graphic design can be seen as an alignment with the wider discourse of design, and involved a re-signification of many practices previously seen as art practices to design practices. Alongside this was a new historical trajectory, which saw the foundations of graphic design, less in fine art discourse and more in the design based practices of the Bauhaus, which emphasized and legitimized utility and industrial practices. The shift was facilitated by a new aesthetic in print production. This promoted the clean layouts of type and photography that came out of, and fitted more easily to new mechanical processes, than did the previously more illustrative treatments. This shift was complicated by the changing nature of design discourse itself.

In design discourse, Modernism originally had two distinct forms. The first, commercial Modernism was primarily American. It was dramatic and emphasized the spectacle, taking its guide from Hollywood, and by association, the visually resplendent art deco, and was firmly based in popular culture. Years later, Raymond

Loewy, doyen of its legacy – the aerodynamically curvaceous Streamform – would state his favorite curve was the sales curve heading upwards [9]. As Heller [10] notes: “It was the profit motive, not any utopian ethic, or any esthetic ideal, that paved the way for commercial modernism in the U.S.” In opposition to this, High Modernism could be seen to have a closer connection to fine art. It had come from Europe, and like art discourse, had a powerful hierarchy of key figures like Le Corbusier and Mies van der Rohe, a new language of design principles (form follows function, less is more, and the like), a privileging of academic discourse and institutions, a legitimacy conferred by important and expensive projects, a multitude of publications, and a show devoted to its work in the Museum of Modern Art [11]. Berman notes how the publication produced by MOMA would “define the modern canon for the next forty years” [12] Proponents of High Modernism would often see the ‘popular’ alternative as vulgar [13].

As graphic design to some degree came out of, and aligned itself with design discourse itself, it embraced much of the language, historical trajectory and values of High Modernism. Yet much of the initial work for graphic designers came from advertising agencies – indeed it can be seen to a large extent as having sprung from the changing needs of these agencies to make their productions more visually appealing. The professional look required a more nuanced appreciation of type and layout than had previously been needed.

One of the reasons the emerging discourse of graphic design was predisposed to an alignment with High Modernism can be seen in one of the dominant historical trajectories which led to, and became a component of the discourse: that of book design and the related notion of typography. Indeed, the term ‘graphic design’, was coined by advertiser, but also book and typeface designer, W.A. Dwiggins [14] and Heller [15] notes: “it suggested a higher calling than does the now unfashionable term, commercial artist”. Whilst typography had been primarily the concern of printers, a ‘refined’ version of typography had emerged in the late 1800s. This is a historical trajectory that emphasises the creative as connected directly to art discourse. This lineage tends to follow the same historical progression as that of printing history up until about the time of the Arts & Crafts period, when fine art and printing reach

a climactic embrace. In 1891 William Morris founded the Kelmscott press, one of the key highlights of typographic histories in design literature [14]. Morris’s press was to spawn a generation of artistic printing but more importantly was to set a language for typography as it could emerge in the discourse of design. Shortly after the Kelmscott Press opened, Charles Ricketts founded the Vale Press (1896-1903) and Kinross [16] makes the following observations:

*He may stand as one of the clearest representatives of a new figure who appears in printing and publishing at this time: the book designers... Before the appearance of the book designer, ‘designer’ had, in the context of publishing, meant essentially ‘illustrator’. The work of Ricketts, and other designers for commercial publishers of the late nineteenth century, represents the incursion of art into machine production (p. 38)*

Kinross notes that “artistic printing occurred at the moment when a change in taste became apparent: between highbrow and lowbrow, between a minority and a mass-market” (p. 40). Thus, graphic design can be seen to be the emergence, initially at the fringes of the printing industry, of a practitioner with a more recognized artistic sensibility. To what degree the new aesthetic was a cause or a consequence of this change is debatable. What is important is how this aesthetic focus shaped graphic design.

In 2002, Satellite [17] interviewed a noted typographical designer and the prelude to this interview is revealing:

*He walks into the basement of Eshleman, our interview spot, and homes straight in on a framed poster leaning against a corner. “THIS IS A PRINTING OFFICE,” the elegantly printed and not entirely subtle sign says, “CROSSROADS OF CIVILIZATIONS, REFUGE OF ALL THE ARTS.” Andy Crewdson stands next to the sign, his neck craned down at it, and says practically without introductions: “That’s a Beatrice Ward from 1932. That’s really cool.”*

*I look at the sign and he’s right (the sign is a reprint), but he’s right on both counts. Andy, a senior who has more or less devoted his free time to typography and reviving long out-of-use typefaces, goes on for about a minute about the history of the sign (Ward created several important typefaces), the methods of printing it (Letterpress), and its*

rarity ("You don't see many of those"). He has all this to say about a sign hanging in my own office, a sign that I'd only given half a look at about three years ago, and it occurs to me that this is what graphic design is all about: recognizing type. (n.p.)

We can see here how the author recognises the language of typography as the language of graphic design, but it is equally important to understand the nature of this language – that is, one which has all of the mystification of the discourse of fine art. Aside from the misspelling of Warde's name (a common mistake), there is an unmistakable quality of traditional fine art connoisseurship within this article. "That's a Beatrice Ward from 1932" smacks of the elevation of the artist's significance over the work, similar to how one might say "The Picasso is in the hall" or "We've just purchased a Rembrandt". The author is quick to point out the work is not an original but a reproduction, even though the work is a piece of printed copy. The language of fine art connoisseurship is unmistakable. I argue that in most design departments of universities and colleges, graphic and communication design is taught largely through a connoisseurship model. This is especially so, when it comes to typography. One of the most popular typography textbooks, *Stop Stealing Sheep* [18] describes the difference between the expert and the amateur:

*It is a bit like having been to a concert, thoroughly enjoying it, then reading in the paper the next morning the conductor had been incompetent, the orchestra out of tune, and that the whole piece of music is not worth performing in the first place... The same thing happens when you have a glass of wine. While you might be perfectly happy with whatever you're drinking, someone at the table will make a face and go on at length why this particular bottle is too warm, how that year was a lousy one anyway... (p. 17)*

Although Spiekermann & Ginger use their metaphor to emphasise that there are different ways to appreciate type, their association of the type expert with the traditional connoisseur points to notions of refined versus unrefined taste.

There are numerous benefits offered by the connoisseurship approach. In the first place it offers individuals a sense of belonging. Well-respected

Australian designer Alistair Morrison had this to say about typography:

*I like the discipline of it. I've always had the feeling of satisfaction of belonging to an international and almost timeless brotherhood which included people like Bodoni and Aldus Manutius, a feeling that I am just another link in the chain. [19]*

For students, this sense can be a powerful incentive to learn, and staff have commented that students have 'found themselves' after discovering the world of typography. These students are given constant reminders of their newfound abilities, skills in type recognition and aesthetic discrimination by the world around them. Every menu, road sign, and website offers up delicacies to be savoured, or crimes to be abhorred. Every unrecognised font becomes a challenge and each challenge becomes a reminder of the club of which he or she is now a member. As Garfield [20] notes: "Identifying a particular font can be the most infuriating task, and designers can spoil their whole day by walking past a shop and seeing something they can't name" (p. 174). Students become more immersed in their art than any teacher could otherwise hope for, and soon know as much, if not more about the subject, than their professors. Genuine engagement is the best of tutors. The joy felt by the student is a combination of deep aesthetic appreciation and the kind of excitement one has at demonstrating (if even only to oneself) a finely tuned skill. This can be an immensely rewarding experience that sees them not only develop an interest, but often, sets them on a career path, with a fascination and deep sense of enquiry that lasts a lifetime. The flow on effects in terms of self-confidence and personal sense of direction are immeasurable.

There are a number of problems, however, with the connoisseurship system. The fascination with what is, that is, with the tangible, can work against the recognition of what is not; of what is missing from the picture. The connoisseurship model privileges object at the expense of context; detail at the expense of wider philosophical or sociological perspective. Furthermore, the connoisseurship model acts to maintain and propagate class distinction, not only in the producer of type, but also in the consumer. For the model to work, a correlative degree of mystification around

aesthetic values is supported—a form of distancing of the language of type from the uninitiated. Bourdieu [21] reminds us that the language of art is a language of exclusion which privileges certain social groups over others, noting that “the ‘naive’ spectator cannot attain a specific grasp of works of art which only have meaning—or value—in relation to the specific history of an artistic tradition.” (p. 4) The danger of this in graphic design education is that students who have learned their art through this approach are well-suited at designing logotypes for banks, law firms, and other elite clients, but often tend to see what they constitute as ‘good design’, as universally appropriate. This means that, as graphic designers, they are limited in their abilities to communicate to anyone outside of the ‘high design’ aesthetic. The emphasis of the connoisseurship model is very much more on the producer, rather than on the consumer, and although it may be recognised that what is deemed good design changes over time, there is still a certain essentialism in the value system. This approach can thus also set up an antagonism to more commercial interests and some designers find themselves antipathetic to areas such as marketing and advertising. Heller [22] makes the following observation:

*The word ‘advertising’, like ‘commercial art’, makes graphic designers cringe. It signifies all that sophisticated contemporary graphic design, or rather visual communications, is not supposed to be. Advertising is the tool of capitalism, a con that persuades an unwitting public to consume and consume again. (p. 112)*

Although an artistic sensibility was present in the emergence of graphic design discourse, it must be noted that this is a simplified picture. Ken Cato notes that while some advertisers were initially wary of the emergence of independent design studios, others saw the potential benefits and were quick to form relationships with them, and many graphic design studios came out of designers originally learning their craft in advertising agencies [8]. Designers also come from many different backgrounds and have different perspectives on the value of connoisseurship approaches to design. However, graphic design education has often not had the diversity of voices present in industry. Jones [23] notes how the majority of design teachers in the new graphic design courses in polytechnic colleges of England had only fine arts training.

Questions around the degree to which art teachers have a place in design education have surfaced a number of times over the past forty years, particularly since small colleges have been absorbed into larger institutions. Ashwin [24] made the comment in 1978 that changing conditions demand a concurrent questioning of the place of art history in design studies and went on to note how “the study of design often requires an economic, technological or sociological mode of analysis which plays little or no part in conventional courses in the history of art” (p. 99). Although this has changed significantly for many art courses, I would argue the connoisseurship approach of fine art was a comfortable fit with that of the High Modernist typographic and book arts trajectory of graphic design and has been thoroughly embedded in graphic design pedagogy since its establishment in tertiary education systems.

Ameliorating some of these differences are shifts in industrial practices, whereby graphic designers have worked closely with marketers and found, on occasion, that they are not completely bereft of creative thinking, or an appreciation for aesthetic considerations. At the same time, the phenomenal rise of the Internet as a commercial landscape has reshaped design pedagogical practices. Website designers cannot limit themselves to the graphic treatment of a site, but must also consider its navigation, and with users able to choose different navigational pathways the design of the ‘experience’ has become a crucial consideration. Even logos, which were at one time simply two-dimensional graphics, can now have 3D aspects or may be built to deliberately change over a period of time. In the workplace, companies began to recognize their branding was far more complex than graphic elements on a page and could involve even the way someone answers the phone. This has led to branding that looks at the entire structure of how a company communicates with their clients, and previous graphic design companies have become brand architects. These more holistic perspectives saw the emergence of communication design courses, which moved the designer one step closer to industry and further from visual arts.

### **3 The argument for a semiotics foundation in design education**

In design discourse, a number of compelling arguments

against semiotic pedagogical approaches are often raised—that semiotics is more directed at analysis rather than creation; that semiotics is too theoretical whilst design is practical, and that it has leftist underpinnings that can turn design students off their intended vocation. However, I would make the case that there are strong arguments against each of them, and many powerful reasons for a deeper and more comprehensive utilization of semiotics in design education.

That semiotics is often seen as passive has been addressed in the past through attempts to re-read semiotics as ‘visual rhetoric’. Rhetoric comes from the notion of constructing a persuasive argument, and some approaches have attempted to use this to promote a more active notion of semiotics. Whilst the area has spawned much valuable research, I would argue that as an approach to designing, it is flawed. It tends to reproduce linguistic models which result in ‘recipe book’ approaches incompatible with the design process. It seems ludicrous, for example, to suggest a designer might ponder whether what is needed in their image is chiasmus (two figures conveyed with attributes of each other) or antimetabole (two characters portrayed where one is upside down or otherwise uncomfortably portrayed). Whilst a repertoire of rhetorical tropes in visual form may provide inspiration when the well is dry, it does little else. Instead, I argue for the development of a semiotic sensibility – an inculcation of semiotic approaches (employing notions of ‘connotation’, ‘myth’, and the like) to expansive subject matter, and with specific attention to how designs work on audiences. These may be developed in the student psyche by analyses of design artifacts as diverse as film, advertisements, packaging, logos, typography, products and even architecture. A great strength of semiotics is the ability to apply the same system of analysis to a variety of products and to be able to use a single language for the communicative aspects of wide ranging subjects.

Any criticism of semiotics as passive neglects the critically important reflective and evaluative components of the design process. Creative aspects of this process are often described as flashes of insight, or ‘the magic’, working off intuition or tacit knowledge. What is referred to here may be more usefully seen as the subconscious formation of connections between different, often unrelated elements, leading to

fortuitous results. We develop the propensity for this ability through creative process techniques, including brainstorming and the like. It has also long been recognised that the more experience one has, the more cognitive potential there is to draw upon, and many design tutors will suggest to students that they not spend all their time in books but experience the world for themselves. A semiotic sensibility can not only contribute significantly to ways of processing experience, it is also directly applicable – as documented in the field of marketing [see, for example 25, 26, 27] – to the reflective and evaluative aspects of the design process. ‘Evaluating’, whether quantitative or qualitative, often involves the use of intuition or tacit knowledge. The rational (or ‘reason-centric’) model of the design process includes production and evaluation ‘loops’ at various points in the process. This might be formalized in the sense of a number of iterations [28] or be informal, in the sense of thinking, developing, back-tracking, re-thinking, and so on, in the “plan-driven problem-solving” approach [29]. In more action-centric models, exemplified by Schön’s [30] “reflection-in-action” paradigm, the act of designing is as much about ‘problem-making’ as it is about problem solving, yet primary emphasis is placed on reflection and evaluation. Design thinking paradigms [31-33] formalize the prototyping and evaluation stages of designing [34], where abductive reasoning is an important feature [31]. In abductive reasoning the pool from which the best ‘guess’ can be made is enriched by a semiotic sensibility. Furthermore design thinking foregrounds the user experience, which is also a strength of current semiotic approaches [25, 27]. Understanding how designs work on audiences can lead to asking the right questions. Far from being relegated to the strictly theoretical realms, a semiotic sensibility can add significantly to design practice.

One of the most powerful aspects of semiotic analysis is its ability to view a text from different contexts—to denaturalize the text. In this way a text can be explored in terms of its possible social and political implications, where the contexts most commonly used foreground issues of class, gender and race. As Kress and van Leeuwen [4] argue:

*Pictorial structures do not simply reproduce the structures of ‘reality’. On the contrary, they produce images of reality which are bound up with the interests of the*

*social institutions within which the pictures are produced, circulated and read. They are ideological. Pictorial structures are never merely formal: they have a deeply important semantic dimension. (p. 45)*

This raises the criticism of semiotics in design discourse that it politicizes the design process. This can be seen as unnecessary or worse; that it may put students off becoming designers. We might ask whether designers even need to take this extra step; whether we need to know any more than what Hall [35] calls the 'preferred meaning' of a text. When we are aware of how an object or message 'speaks to' consumers, we raise consciousness of how that artifact acts in culture – which beliefs or values it supports and propagates. For example, a purely aesthetic treatment for a new brand of deodorant might present few moral difficulties for the designer; whereas an awareness of how a product can appeal to a woman's insecurities about her self-image that might result in higher sales, creates a moral dilemma. The designer who believes they are only communicating an aesthetic is, of course, communicating much more, although they may be ignorant of the inherent messages in their work. I suggest there are two important reasons to ask what a text does, that is, what values it promotes, or ideological positions it propagates, beyond the preferred reading. The first is that this leads to a deeper awareness and appreciation of how our designs communicate messages, developing our 'semiotic sensibility'. Secondly, almost all university design courses have identified "globally aware and ethically responsible" as desired graduate attributes. I take Freire's [36] perspective that everything is political that, in fact, one acts politically whether one recognises it or not. As Atzmon notes:

*If they are not trained, designers may not even be aware of the meanings underlying their process and the communicative power of the choices they make. Whatever the design process, though, the designer's beliefs and attitudes shape choices made about the material form. The designer's aesthetic convictions are necessarily influenced by the culture(s) in which the designer is immersed, and the material form of the design object embodies these beliefs and attitudes. [37]*

If there is social imbalance and one acts within the social sphere, then one acts to maintain that imbalance or to

critique it. A designer who is ignorant of the effects of his or her actions, still acts. A semiotic sensibility has potential to contribute significantly to the formation of globally aware and ethically responsible graduates. As it is, fears that students will be put off the course are unfounded. Not only has the course I teach in semiotics had continuously excellent student feedback, but also I have had numerous students impart to me that the course has "changed their life", and added immeasurably to their appreciation of design. Even many years later, ex-students have told of the lasting impression from their course in semiotics and design, which positively affect their work still.

I have worked for a number of years at both RMIT and Swinburne University in Melbourne and currently at AUT University in Auckland developing a semiotics approach to design. This is initially imparted through a series of lectures and tutorials. Lectures include an introduction to semiotics, with explanation of signification, notions of myth and ideology; Marxist theory; and critical approaches to the politics of gender and race. A series of assignments move the student from a general familiarization with the language of semiotics to gradually more applied semiotic analyses:

1. *Visual diary*: students are invited to take the concepts discussed in lectures and apply them to their lives outside of the university environment. Each week, they bring their photographs, found images and other media, along with annotations discussing these in terms of semiotics. This works well in allowing students to discover implications of our semiotic evaluations for their own world.
2. *Film analysis*: this is an essay where students are given articles that use semiotic theories to analyse films. They then choose a particular perspective from the lecture series (Marxist, gender or race politics) and using this perspective, analyse a film taken from a list provided. Students must identify signifiers, and myths and suggest ideological impact. For example, a Marxist analysis will involve identifying signifiers of class in the film, and myths related to class, and discuss how the film therefore critiques or propagates certain ideological positions with respect to social class.
3. *Label swap*: this project has long been a part of many design curricula. Two products that appeal to different target markets are chosen. Keeping the

products in their packaging, and leaving the words on those packages, all other signifiers (colour, typefaces, layout, style of images, and the like) are swapped, such that one product's expressive language is transferred to the other and vice versa. The importance of the assignment is in the awareness it brings of precisely which elements in packaging constitute signifiers – which 'speak' to the target market in a particular voice – and which do not.

4. *Magazine swap: this works in the same way as the label swap except involves exchanging the signifying elements of two magazines with differing target markets. For example, in a Marxist approach, the signifiers (apart from the actual words) of Womens' Day might be swapped with those of Style. The results are then analyzed in terms of how the 're-signified' magazines now speak to their target markets in terms of class.*
5. *Product analysis: students again take on a particular perspective from the lecture series, and apply this to the analysis of packaging and advertising of a simple supermarket product. Again, the student attempts to elucidate the 'voice' of the product as it speaks to its target market, along with any myths used to appeal to that market, and the possible ideological impact of the use of these myths.*

Students are then given the opportunity to apply their semiotic sensibility in real world social innovation projects with important social justice outcomes. This is vitally important as it offers alternative ways for design students to envisage their future, rather than the usual maintenance and support of a consumption-based economy. Some of the projects students have worked on include:

1. *Such Lives: This project<sup>1</sup> involved the creation of animatics as part of a large-scale theatre production with residents of the Fitzroy housing estate in Melbourne. The residents were a deeply underprivileged community who had lived on the estate for three or four generations. Students reported that the experience not only dramatically impacted on their lives but importantly, on their sense of the meaning and potential of design.*
2. *Unreserved: A series of animations to save an important historical and social landmark from developers. Working with oral histories from past workers and residents at the site, students*

constructed animations, which successfully brought together the community and saved the site. Students and their parents reported that they could not believe that design students could do such significant and powerful work as part of a university course. The work is now part of the permanent collection of the Australian Centre for the Moving Image, Melbourne.

3. *Same Difference Exhibition: in this project<sup>2</sup> students worked with the ALSO Foundation (an organization that represents the rights of GLBTI communities) and the Department of Justice to produce posters to reduce discrimination. An exhibition of these posters was launched at the Justice Museum in the week that a report that identified potential strategies aimed at reducing homophobia was handed over to the Attorney General. As a result of the two pronged approach, the written report and the highly visual exhibition, significant legislative reform is now being considered and funding was provided to the ALSO foundation to mount a statewide anti-homophobia campaign, which was launched in August of last year.*
4. *Equal Service: a digital storytelling project<sup>3</sup> that took place in Australia as an adjunct to a larger project initiated by the State Government in conjunction with the Homeless Persons Legal Clinic (HPLC) and the Council To Homeless People (CHP). The aim was to work cooperatively to address the discrimination that people experiencing homelessness receive whilst trying to participate in public life. Students produced a DVD of animated stories to be sent out to service providers in Victoria. The project was launched by the Attorney General and was so successful, it was decided the DVD was to be sent to all states in Australia.*
5. *Altered Lives: Students from Auckland University of Technology (AUT) collaborated with Positive Women to produce a series of digital storytelling projects<sup>4</sup> aimed at de-stigmatizing what it means to live with HIV. This was sponsored by Positive Women and Mac Cosmetics and was launched this year. Focus group testing has revealed the digital stories have a profound effect on audiences, with one respondent recently diagnosed with HIV commenting that she had considered suicide until this life-affirming work gave her hope for a future.*

These projects are not only dynamic and powerful tools for instigating change in communities, but also

<sup>1</sup> A report of this project can be found at [38] Young, A., and Gray, B., 2012, "Empowering Art," Cumulus Conference 2012: Northern Mandate, Helsinki, Finland.

<sup>2</sup> For a report of this project, see [39] Gray, B., and Young, A., 2013, "Communication Design and Community: Pedagogy and Empowerment," Proc. Crafting The Future: 10th European Academy of Design Conference, Gothenburg, Sweden.

<sup>4</sup> For a report of this project, see [38] Young, A., and Gray, B., 2012, "Empowering Art," Cumulus Conference 2012: Northern Mandate, Helsinki, Finland.

<sup>5</sup> For a report of this project see [39] Gray, B., and Young, A., 2013, "Communication Design and Community: Pedagogy and Empowerment," Proc. Crafting The Future: 10th European Academy of Design Conference, Gothenburg, Sweden.

work to demonstrate first hand to students that their communication skills can have dramatic and very personal benefits for others. There can be no proof that a semiotic sensibility helps students to design better, just as we cannot prove that reading will make someone a better novelist. Yet students report that learning semiotics has significantly enhanced their understanding of how ideas, values and beliefs are communicated through designed artifacts. The combination of imparting the language of semiotics with an ability to decontextualize design artifacts – illuminating how they communicate with their audiences is overwhelmingly valued in student evaluation reports of the subject. The development of their skills through real projects seems to be greatly enhanced by their semiotic sensibility.

Semiotics is neither an a priori, nor a universal, fixed system. It is a culturally specific model that can be used to structure and categorize ways of seeing. It can be applied equally to the products of graphic design, industrial design, architecture and any other system that produces artifacts that communicate to an audience or market. Rather than a recipe book approach to understanding design, I argue for a gradual inculcation of a semiotic sensibility, which provides students with a wide range of contexts through which to understand both the connotative meanings of their work, as well as the wider social and political implications it carries for specific audiences.

Although the historical trajectories of design and graphic design discourses have worked to militate against any significant inclusion of semiotics in graphic design pedagogy, semiotics can provide a rich foundational system for design education. This will not only advantage students in their design practice directly, but will significantly contribute to the other important pedagogical systems through which they learn to become better designers and more informed people. As design approaches are becoming more centered on the people who use our designs, rather than on the expert or connoisseur designer, and as global issues demand more aware and ethically responsible design, a semiotic sensibility is vital if design pedagogy is to be relevant and inspirational.

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# Three dimensions of lace: Reading the meaning of a traditional product from different perspectives

## **Abstract**

This paper examines the artifact of lace in three different contexts in Turkish culture: It is the product of a craftsmanship tradition; it is the object of lace making activity; it is the signifier of the home concept. The aim of the study is to approach to this artifact with a culturally rich background, from different perspectives and provide an insight to understand the daily social life. Focusing on the 'meaning' of products and artifacts, it is studied how a product of material culture can transport different meanings and be constantly transformed within the interpretation of its makers/designers and users/non-users.

## **Keywords**

Lace, material culture, craftsmanship, home, design research, symbolic interaction

## **1 Introduction**

Lace is defined as a fine open fabric of cotton or silk, made by looping, twisting, or knitting thread in patterns and used especially for trimming garments (Oxford Dictionary 2012). It can be made by hand or by knitting machines. Based on how it is made, lace can be classified, such as, needle lace, cutwork, bobbin lace, tape lace, knotted lace, crocheted lace, knitted lace, machine-made lace, chemical lace, and the examples can be increased with every new developed technique. Lace can be used as part of clothes or as decorative element

in the house. There are several countries and regions, which have their own characteristic lace depending on their traditional cultural background; some of them are French lace, Turkish lace, Italian lace, Hungarian lace and Finnish lace.

This study, methodologically positioned in the intersection of product semantics and symbolic interaction, examines the artifact of lace with its three dimensions: First, it is taken as a product of tradition; second, it is examined as the object of a joint action, in terms of lace making; and third, it is examined as the signifier of the home concept, in Turkey.

## **2 About Turkish lace**

Among many other types of lace, this study within its scope focuses on the Turkish lace. Turkish lace is used as an essential decorative ornament in Turkish houses. It is made using crochet hooks and needles. Considering the traditional structure of Turkish lace the most preferred threads are cotton and silk, and the most preferred color is white. However, there is a huge variety in the type and color of the threads, which are used for lace making. There are basically two main variations of Turkish lace: One of them can be applied on several types of cloth surfaces and edges, such as, towels, curtains, bed linings, headscarves, and etc. This kind of lace is called 'needlework'; their patterns

and names change according to the region it is being made. Today, the needlework is also being used in order to design 'fabric jewelry' and decorative goods (Yalcinkaya 2012).

Adding same or different patterns together and building a surface by using crochet hooks make the second variation of lace. With this technique, tablecloths, curtains, bridal dresses, bedcoverings and clothes can be made. This kind of lace is usually made in geometrical shapes and it consists of unique patterns, which come together and build the whole lace. The size and number of patterns can vary.

Leaving its physical characteristics aside, lace with all its connotations related to tradition, cultural practice and home concept in Turkish culture is more than a domestic artifact in Turkey: It has several meanings for its maker, its user and even for its 'non-user'. Therefore to examine lace and lace making activity provides an insight for understanding the Turkish culture and everyday life.

### 3 Perspective and method: The intersection of design research and symbolic interactionism

Product semantics, as a field of design research, deals with the meaning and interpretation of artifacts. It aims to "understand users' understanding of their practices of interfacing with designed things and provide strategies for designing products that can either afford or supportively intervene in that understanding. (...) Product semantics recognizes that people surround themselves with things they are familiar with, are able to handle effortlessly and can arrange so as to feel comfortable among them" (Krippendorff and Butter 1984).

The approach of product semantics brings back the individual user who is capable of understanding, practicing and interpreting products instead of the imaginary 'average user' which needs fool-proof products. Thus, it focuses on the 'meaning' of the product which is settled by the individual user and assumes that 'Design is making sense of things', as Krippendorff (2006) has stated.

Considering that design research is not as quantifiable as in science and engineering it requires an

interpretative process, which is needed to understand human behavior and sensitivities because many human cultural values are embedded in the interpretation of phenomena.

With respect to the claim 'Design is making sense of things.' (Krippendorff 2006), the meaning of an artifact sits in the core of its design. However, this meaning cannot be absolutely determined by the designer but has to be recreated in every use and every context by the individual user through a process of interpretation. This product semantics approach takes the absolute 'meaning giving' authority from the designer and supports to see users and non-users as individual interpreters of the artifacts and find their own 'meanings', similar to Barthes' (1967) 'dead author/ity'. Considering that "there is no embodied knowledge in the artifact until it is interpreted" (Mäkelä 2006), the approach of the design research gets closer to the perspective and method of symbolic interactionism.

As Blumer (1969) states, symbolic interactionism has three main premises:

1. Human beings act toward things on the basis of the meanings that the things have for them.
2. The meaning of such things is derived from, or arises out of, the social interaction that one has with one's fellows.
3. These meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he encounters.

The symbolic interactionism sees meanings as social products as creations that are formed in and through the defining activities of people as they interact. This approach corresponds to the attitude where a product is best evaluated according to its meaning for its user or non-user. Thus, it is the context and the social interaction, which helps the individual to make sense of objects and products.

To summarize, the methodology of the paper combines both perspectives of product semantics and symbolic interactionism focusing on the meaning of a traditional cultural artifact, an element of the Turkish material culture. As Denzin (1992) states, "The production, distribution, consumption, and exchange of cultural objects involves issues of ideology and the political

economy (semiosis) of signs, including how these signs are worded or photographed, where they circulate, who buys them, and so forth. The systems of discourse that shape the meanings brought to any cultural object must also be examined."

An ethnographic inquiry among a group of people revealed various experiences and approaches related to lace and lace making. Considering that ethnography is the work of describing a culture the attitude is based on learning from people rather than studying people. Thus, instead of collecting "data" about people, the aim is to learn from people, to be taught by them (Spradley 1979). With this perspective, semi-structured interviews are conducted with people from different age, gender and educational backgrounds. The interview questions are formulated in order to get information about lace and lace making, its usage at home, its cultural perception and its meaning for Turkish people. Thus, the aim of the ethnographic inquiry is to have an understanding of the existence and use of lace in everyday life; to determine its relation and relevance to Turkish culture, and, finally, to identify its users and different forms of usage including past and recent situations.

Besides semi-structured interviews, conversations, as a part of the methodology, are conducted many times with these people. Considering that conversation is a cooperative venture, it has a direction and it allows new understanding (Feldman 1999), the transmission of knowledge through an informal conversation provides the transmission of some kind of tacit knowledge regarding the issues of daily life. Furthermore, observations support the data that has been reached through interviews and they help to recognize the unstated situations and, photographs have been taken in participants' houses so that a visual analysis can be made with the documentation of data (Pink 2007).

## **4 Different approaches to lace in Turkish culture: A product of tradition, an object of joint action and a signifier of home**

### **4.1 Lace as the product of tradition**

Lace as a traditional handcraft is very popular in Turkish society and lace making is one of the favorite activities of most Turkish housewives. It is a transmitter of a

tradition and culture with a strong emphasis on the importance of hand labor. Grandmothers pass this tradition to mothers, mothers to daughters, and so on. Examining the lace in its traditional and cultural context, its connotations can be read through the reading of the 'tradition' and 'craftsmanship' concepts.

In order to get an insight about the meaning of a traditional craftsmanship product and this concept's contribution to the perspective of this study a brief look at the meaning of tradition and craftsmanship would be helpful. Starting with the definition of 'tradition', it is the transmission of customs or beliefs from generation to generation, as well as, an artistic or literary method or style established by an artist, writer, or movement, and subsequently followed by others (Oxford Dictionary 2012). Tradition contains every kind of belief, images of individuals and events, techniques and institutions (Shils 1981). Thus, cultural traditions are a continuation of the past, as well as a projection into the future, actually being elements of the continuity of a society's history. At this point, craft products can be taken as one of the transmitting elements of culture and tradition. Craftsmanship and so, craft products, are material beings in the intersection of culture, tradition and society since historical production techniques and rituals generate them. It is important to see craft products with their cultural depth because they are not only products of traditional hand-labor but also carriers of the tradition itself. A craft product offers the user to get informed about its cultural background visualizing the traditional usage of the artifact. Due to this kind of communication, the relation between the product and the user becomes a cultural interaction happening on a personal experience for each individual in the society. Also, this situation allows the user or the subject to share the traces of the unique object's or craft product's moments of creation (Baudrillard 1968):

"The fascination of handicraft derives from an object's having passed through the hands of someone, the marks of whose labor are still inscribed thereupon: we are fascinated by what has been created, and is therefore unique, because the moment of creation cannot be reproduced. Now, the traces of creation from the actual impression of the hand to the signature, is also a search for a line of descent and for paternal transcendence". Various interpretations of culture and tradition show

that these two concepts have the power to define and transform each other. Craftsmanship, in addition, is a 'product' of them both; a more concrete outcome of their reflections on the society. Thus, the concept of craft products includes histories, cultures and traditions of societies; like myths, which transform a meaning into a form (Barthes 1957). Craft products, like all other products, have their own language, however their languages are configured over a longer period of time and in a cumulative way. Thus the relationship between the user and the product is defined by a cultural and historical involvement with the related tradition, i.e. an internalization of the tradition by every individual since the craftsman's cumulative work is actually the cumulative work of every individual by means of society.

Several patterns, techniques and even names of lace types, which vary according to the local region they are being made, are a reflection of the related culture, tradition and life style. Thus, beyond any kind of meaning that is attributed to it, the lace is a transmitter of tradition and culture. It builds a connection from past generations to the present and future carrying the traces of a tradition and being regenerated with every new contribution. During this process, its meaning is recreated by each individual and transformed to the next. This dynamic situation provides a constant transmission, transformation and interpretation of the meaning and artifact of lace in the context of tradition.

#### **4.2 Lace as the object of joint action**

Lace making activity is identified with women, especially with housewives in Turkish culture. It is the activity, which is being done by housewives at their 'home meetings'. Home meeting is the social activity of housewives where a small group of friends gets together with certain periods. The meeting happens every time in another woman's house, and the owner of the house is responsible with hosting the others with food, service, and etc. Housewives enjoy home meetings and they have conversations together about their lives, recipes, practical solutions at home works; they share their own experiences and thus learn from each other during these conversations. One of the subjects of these conversations is handicraft, which shows the talent of the housewife. Completed laces are shown and sometimes they are sold in the group; new patterns are shared and taught to those who ask for them.

Thus, lace-making activity accompanies the conversation, although it is generally not the focus of the conversation.

According to Mead (1967), objects consist of whatever people indicate or refer to. Considering lace as the object of lace making activity, it is the object of a joint action covering the socialization through exhibiting, teaching and practicing together. Quoting Blumer (1969), "Objects are social products in that they are formed and transformed by the defining process that takes place in social interaction. The meaning of the objects is formed from the ways in which others refer to such objects or act toward them." For the one who exhibits her talent, lace is the object of a 'show'; for the one who teaches to make lace, it is the object of being the 'master'; and for the one who is practicing, it is the object of a 'common sharing'. These differing meanings define the differing positions of each individual in this group, because they tend to act on the basis of their own meanings.

Lace, as the object of the joint action – lace making – is constituted through social interaction in terms of its material being, meaning and use. Blumer (1969) defines joint action as the "larger collective form of action that is constituted by the fitting together of the lines of behavior of the separate participants". Considering that anything can be an object to an individual, it is one of the examples, which has a variety of connotations and meanings. Within the context of this study, some of them are material culture, tradition, craftsmanship, womanhood, social interaction and home concept. As mentioned above, the meaning varies according to the interacting individual and the context, and lace is one of the objects, which can help to understand the culture and lifestyle of an individual or a group of people by identifying it and its environment. As Blumer (1969) also states, "Since people are set to act in terms of the meaning of their objects, the world of objects of a group represents in a genuine sense its action organization", and this corresponds to the action organization in the housewives' group, positioning themselves according to the meaning of lace making activity.

#### **4.3 Lace as the signifier of home**

Lace has always been a signifier of the home in Turkish culture. Generally, it is identified with the womanhood of the housewife, her talent and dominance over the

house and her success in turning the house into a warm home. According to (Bachelard 1969), our home is an extension of our existence and it is the representation of our existence. Thus it reflects us as well as our position in life, and it is our first point of communication with life (Fidanoglu 2001). The concept of home is always remarkably distinguished from the concept of a house or a flat in Turkish culture. Most of the time, it is the signifier of a family, warmth and a feeling of safety that is the capturing of a certain piece of the world.

The very first examples of the Turkish house were built on soil ground, with various isolation material and it consisted of a single huge room for different activities, such as, eating, sleeping, sitting and storing (Goker 2009). Since rooms in traditional Turkish house were designed as volumes having many functions, objects used in these rooms became also portable and multifunctional, such as cushions, floor-beds, floor-tables, and many others constructed with cloths. A characteristic of traditional Turkish house was the sofa, the center area of the house to which all other rooms have direct connections. Sofa was the place where all members of the family can spend time together and also, where guests are hosted. Within the urbanization process sofa has lost its power and importance in gathering people together and, as a result, sofa disappeared in urbanized areas' (Eric, Ersoy and Yener 1986). For the new structure of Turkish house from 1960s to late 1990s in urbanized areas, it is possible to claim that the house consisted of two main parts: The inner house, where the family lives, and the salon, where guests are hosted. Conceptually, the inner house means sincerity, nearness, warmth, comfort, directness, density and familiarity, while salon is the world of relationships with 'disturbing' strangers (Ayata 1988). Due to this sharp distinction of spaces in the same house, the family living in there has two distinct worlds, socially and psychologically. The salon was like an exhibition area for guests where all valuable goods of the family are displayed; these could be goods which have been bought and are expensive, such as, a new television, video player, furniture set, or goods which carry the memories or talent of the housewife, such as, hand-woven or hand-knit cloths and laces.

Considering the situation today, the separation between salon and living room is not as distinguishing as it was

before and the fast urbanization bringing the lack of space is one of the factors which make the living room serve both as salon and living room. So, the differentiation between the inner house and outer house is fading. However, among many artifacts, which resist the process of modernization in the Turkish house, lace is the most significant one, which is being adapted to many different situations in the house. Lace in Turkish home concept, is mostly used in order to cover or pack goods. It is used as tablecloth, coffee table cloth, display cabinet cloth, bed linen, wardrobe cloth, and etc. It serves to create a warm, 'dressed' home out of a 'naked' house. This warmth basically signifies the family and safety. As mentioned before, the home itself and its objects become an extension of its user. Putting laces on furniture is like dressing the furniture in order to emphasize its existence, and laces under some decorative objects serve to underline these objects – a certain kind of possession (Baudrillard 1981).

Today, lace is still used everywhere in the house for different purposes: They are placed in the living room, in the bedroom and even in the kitchen. In the kitchen it is placed on visible and covered shelves, under plates and glasses, and etc., in the bedroom it is placed in chiffoniers and closets. In the living room, the lace serves to cover the dinner table, the coffee table (Figure 1), and the shelves of the display cabinet where it becomes an element of decoration (Figure 2).



Fig. 1. Lace on coffee tables



Fig. 2. Lace in the display cabinet

It is placed under vases and other decorative objects so that direct contact and thus a possible scratch to the furniture is avoided (Figure 3).



Fig. 3. Lace under decorative objects

Considering that “the organization of a human being consists of his objects, that is, his tendencies to act on the basis of their meanings” (Blumer 1969), it is the objects, which serve to the creation of the home, of life and identity. It is because there is something referring to old habits, different aspirations, desires, emotions, dreams, individual perceptions of life, and etc. Everyday objects that have become invisible to the user, mostly have become an essential part of his/her life, especially at home. Since people are set to act in terms of the meanings of their objects, the world of objects of a group represents in a genuine sense its action organization. To identify and understand the life of people it is necessary to identify their world of objects and this identification has to be in terms of the meanings objects have for the members of the group (Mead 1967). Young generation's definition of the ‘house’ is mostly a place where little time will be spent, these people still use the word ‘home’ for the place where they used to live with their parents – and with laces although most of them criticize their mothers’ use of lace, and they prefer to use ‘at’ where they live with their friends.

## 5 Conclusion

There are several reasons and many other perspectives on the existence, use and meaning of lace; however, it is examined in this study in the intersection of product semantics and symbolic interactionism. Starting from its material being and existence in Turkish culture, lace is examined through its position in craftsmanship tradition, as an object of lace making activity in terms of creating a process in its process of creation and as a signifier of the traditional Turkish home in its final destination.

Examining lace as a craftsmanship product of Turkish culture provides a brief understanding about the existence and use of lace in its connection to traditional values and life styles: It is one of the many bridges, which connects the past to the present and future and transmits a shared common past. Furthermore, lace as the reason and the object of lace-making activity becomes the organizer of a certain piece of social life where its makers/designers are positioned according to their relation to it: This is where teaching, learning and sharing activities are included and formulated into a type of conversation.

Having investigated the lace in its material existence and process of creation within its social circle, the following stage comes as its signification of home. Since one of the main reasons of making lace is to display the talent and leave a memory and a gift to next generations it is a part of creating the warm home. This is where generations have different approaches: For instance, considering younger generations, especially living in metropolitan cities, they do not prefer to use lace in their houses. It is neither a symbol of hand labor nor an element of decoration for them; it is some unnecessary ornament and a house would be more plain and “modern” without them while older generations believe that a house would be “empty” without lace.

To conclude, lace, like many other objects, has several meanings in different contexts: Within the scope of this study, it is the carrier of a tradition and thus the connection between the older and younger generations; it is the object of lace making, and thus the starter of a social organization process in small housewives groups; finally, it is a remarkable signifier of the traditional Turkish home. Lace in all these different contexts, however, stands with a very strong characteristic, since it is the key object, which provides the repeat of a social act and creates its own ritual.

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# Retracing an Evolution of Meanings for Design-Driven Innovation

## Abstract

In this paper we explore how to enrich design-driven innovation by considering the dynamic nature of such innovation as a result of history and evolution. Design-driven innovation takes distance from users in their current context, but instead proposes radical new meanings to users that address new potential needs. Here we look at how design-driven innovation can be based on a thorough understanding of a product/service's current meanings and lost meanings of its predecessor(s). We investigate this assertion with an action oriented case study using a research through design approach. Within the context of recorded music, and using script analysis theory to define meaning, we studied the evolution of album covers. As a result, we were able to come up with two radical meaning innovations for album covers. We conclude that the investigation of the evolution of meaning of a series of products/services –from the past up to the present– can help designers to depart from current meanings more radically, and more purposefully. We thus hope to inspire design to go beyond studying meanings in temporal isolation, taking into account meaning as a result of history and evolution for the purpose of design-driven innovation.

## Keywords

Design-driven innovation, script analysis theory, evolution of meaning, (design) history.

## 1 Introduction

### 1.1 Background

According to Akrich, artifacts contain scripts (messages) from their designer (and other producers) to the user describing the product's intended use and meanings [1]. The term 'script' here is a metaphor for an 'instruction manual' which Akrich claims is inscribed in an artifact. Products/services have meanings inscribed by their designer (and other producers) within the context of production. Within the context of use, these scripts can be: (1) subscribed to, by users, when inscribed meanings are interpreted and accepted as intended by the designer (and other producers); and/or (2) de-inscribed by users, when scripts of intended meanings are ignored/discarded/rejected/interpreted differently and used for other meaning intentions as intended by the designer. Thus, the meanings of products and services can be found in between a context of production and a context of use [3, 4, 5, 6, 7].

A common assumption has been that the meanings of a design are given; one could attempt to understand them but one cannot innovate on them. Recently, Verganti has argued that meanings can, and should also be innovated upon, using a separate, more culturally informed strategy for innovation [8]. Verganti calls this strategy design-driven innovation and in his book he explains that this is "an innovation strategy that leads to products and services that have a radical new

meaning: those that convey a completely new reason for customers to buy them" (p. viii). While Verganti has emphasized that his book is not about design but management, in this paper we are interested in design-driven innovation both from a management and design perspective. The question we ask is: 'How can designers plan for innovations in the meaning of the products and/or services they create?'

Our research in this direction started by an investigation of what happens when radically new meanings are introduced by a design and designers want to stimulate the adoption of those meanings by users [9]. We worked in the view that meanings of products and services are organized around sociocultural regimes [10, 11, 12]. With this is meant a regulation of the production of cultural symbols, in combination of cultural norms and values in (parts of) society, and artifacts and technologies with particular symbolic meanings [13, 14]. For example, think of the do's and don'ts during a Japanese tea ceremony (regulation), in connection to the etiquette and experience of drinking tea for Japanese users (norms and values), and the symbolic meaning of the used tableware (artifacts and technologies).

In our previous work, we explained that the transformation from one sociocultural regime to a new one could lead to meaning gaps, where radical new meanings are alienating people. The new sociocultural regime is too far from the previous regime, with some existing meanings from a current sociocultural regime being made redundant, causing feelings of culture and identity loss [15, 16]. In addition, we explained how meaning gaps can be bridged through balancing new and existing meanings. From this we learned that the meaning carried by products and/or services have been constructed over a wider, and historical set of predecessors [7]. Meanings evolve over time, and during sociocultural transformations meanings can be: introduced, disposed of, preserved, and/or re-introduced [9].

Yet, in design and innovation research and practice, meanings are often perceived, measured, and dealt with exclusively on basis of a product/service at hand. However, within the current sociocultural regime only part of a product/service's meanings can be perceived, measured, and dealt with. To uncover, and possibly

restore all potential meanings of a new design, it is vital that we look to the evolution of designs over multiple sociocultural regimes. We take our inspiration from Aristotle, according to whom "The essentials of a phenomenon are best understood if one tries to explore their rise from the very beginnings." [17].

## 1.2 Objective

Inspired by the dynamic nature of meaning and meaning as a result of history and evolution, in this paper we investigate how overall established meanings of a product/service in the here and now, can more thoroughly be understood by studying the evolution of that product/service. I.e. how a product/service has become what it is today. In addition to this, we investigate how a thorough understanding of a product/service as well as related possibly lost established meanings can serve the design of radical new meanings. Finally, we investigate the implications that this approach could have for design-driven innovation.

We have depicted 'album covers' as a product for our research, which we base on an action oriented case study regarding the design of a radical home audio system.

## 1.3 Structure of this paper

We start by a literature review describing script analysis theory and design-driven innovation. We continue by introducing the case study and our research context and methodology. Then we present the results of our meaning analysis followed by a radical new meaning synthesis. Lastly, we derive conclusions and define our future work.

# 2 Literature review

## 2.1 Script analysis theory

A methodological tool that can be used for analyzing and understanding the meaning of products and/or services is the script analysis theory. Madeline Akrich developed this tool within the conceptual framework of actor-network theory (ANT) [1, 2, 29]. ANT is a theoretical framework introduced in the latter half of the 1980s by Bruno Latour, Michael Callon, and John Law to emphasize that technology and society are mutually constitutive, not separate spheres influencing each other [7, 29]. While ANT is concerned with

transformation of meaning through artifacts (non-humans as well as human actors) as they form and move through networks and act as mediators, the idea of product script has been developed to facilitate close analysis of how meaning is transported and transformed by products [7].

From a practical and design point of view, we have clarified some terms from the vocabulary of script analysis theory used in this paper. Our clarification is based on the works of Akrich, Latour [1, 2], and Fallan [6, 7] (Table 1).

Term	De nition	Example
Script	Messages from designer (and other producers) of a product/service to the user describing the product's intended use and meanings	"Heavy keys of hostels" with intention "do not forget to bring the keys back to the front desk" [2, p. 259]
Description	Interpretation of messages of a product/ service to generate meanings. This is usually done by the analyst or user and is the opposite movement of inscription	Interpretation of "heavy keys of hotels" would for example be "do not forget to bring the keys back to the front desk" [2, p. 259]
Inscription	Translation of meanings to messages of a product/service by the designer (and other producers)	"Translating the message 'do not forget to bring the keys back to the front desk' by 'heavy weights attached to keys to force clients to be reminded to bring back the keys to the front desk'" [2, p.259-260]

Table 1. Vocabulary of script analysis theory

## 2.2 Design-driven innovation

Design-driven innovation (a.k.a meaning-driven innovation) is an innovation strategy introduced in 2009 by Roberto Verganti as an addition to the two mainstream and dominant innovation strategies of user-driven innovation (a.k.a. market pull innovation) and technology-driven innovation (a.k.a. technology push

innovation) [8]. While user-driven innovation usually departs from user/market studies and technology-driven innovation departs from technological inventions, design-driven innovation departs from the innovator's culture. This strategy is about taking distance from the user/market and sometimes also about the integration of new or existing technology in a new market or sociocultural regime in order to avoid incremental change and aim for change which is more radical. Verganti describes this idea well using his framework on which the different strategies are mapped together with a hybrid strategy what he calls 'Technology Epiphanies' (Figure 1). Technology epiphanies occur when there is radical change interplay between both meaning and technology.

In more recent work [18] on design-driven innovation Verganti has proposed a hermeneutic framework to look at radical innovation of meanings based on the two main acts of 'interpreting' and 'envisioning'.

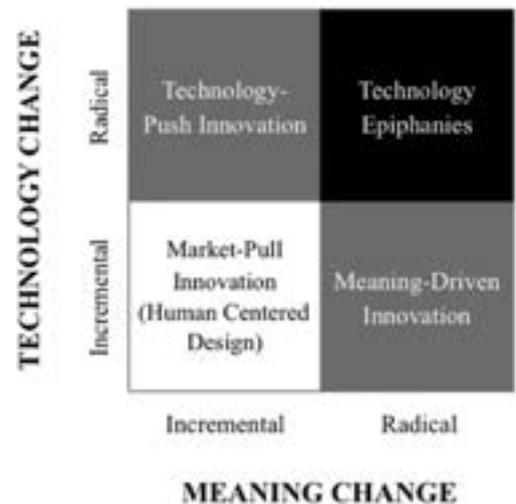


Figure 1. The two innovation dimensions and related innovation types adopted from Norman & Verganti [19]

In this work Verganti has also provided a clarification on how he defines a 'product meaning'. Namely: "To clarify, when we mention 'product meaning', we relate to the purpose of a product/service as perceived by the user. It is about the purpose for why a product is used, not how it is used (the user interface), nor what the product consists of (its features)". The hermeneutic framework and definition of product meaning brings design-driven innovation close to design. However, up to now, the

research on design-driven innovation has been based on post-hoc analyses of selected cases in design, rather than on a design activity that synthesizes new proposals that will depart from current meanings.

### 3 Research context and approach

In this paper we focus on two 'how' questions: (1) Understanding how the meanings carried by a product/service have been constructed over a wider, and historical set of predecessors?; and (2) How insights from such a study, can be beneficial for and used to design radical new meanings?.

In order to answer these questions a 12-week action oriented case study in the form of a design research project was set up between the Industrial Design Department of Eindhoven University of Technology and the Department of R&D&I of Philips and executed by the first author in 2006.

#### 3.1 Design case study and research focus

The design brief for the practical case above was to design a 'radical' home audio system. By 'radical' we mean a product/service created from a radical meaning and possibly technology interplay innovation. In particular, we were interested in a differentiation from existing home audio systems (in 2006) by means of what Verganti later called a 'technology epiphany' (Figure 1) [8]. For the sake of clarity, within this paper we only focus and report on the 'album cover' relating parts of the radical home audio system that was designed. This means: (1) understanding how the meanings carried by album covers have been constructed over a wider, and historical set of predecessors; and (2) how insights from such a study, can be beneficial for and used to design the next generation album cover with radical new meanings.

#### 3.2 Research approach

This case study was based upon a 'research through design' approach and reflective practice. In this approach design action and reflection on action are considered creators of knowledge, and the design outcome is considered the physical proof of the knowledge generated [20, 21, 22, 23].

Our research through design approach was also supported by desk research. Within this desk research

predecessors of album covers were selected and described by the design researcher using various documentations on the Internet relating to album cover history [1]. In total a number of 25 predecessors from 1870s up to 2006 were selected and described.

To complete our research for reporting, we also performed a post-hoc informant inquiry using social media in which we asked informants: 'What do album covers mean to you?'. This question was answered by a number of 32 informants who did not have any knowledge about script analysis theory; i.e. they informally described what album covers mean to them and motivated these descriptions.

### 4 Results

We start by a summary of the informal (i.e. not based on script analysis theory) meaning descriptions inquired from informants through our social media inquiry (Section 4.1). Then we present the evolution of album cover meanings described based on a desk research using script analysis theory (Section 4.2). This is followed by a reflection of the designer on both the informant and meaning evolution descriptions towards forming a strategic design vision (Section 4.3). Finally we present a radical new meaning for album covers within the radical home audio system that was designed (Section 4.4).

#### 4.1 Album cover meaning descriptions from informants

Table 2 provides a summary of the analyzed results. In total a number of 13 meanings (The center column) were described by the 32 informants (random mixed group) that participated in the explorative study.

In order to give a good indication of how the study was done, we have depicted and included a description example for each described meaning (The left column). In the right hand column, we have indicated the number of times that a certain meaning was referred to in the informant descriptions.

Most of the informants describe the meaning of album covers from the artist point of view; i.e. as a platform where the artists can express themselves. Moreover, album covers can be seen as a channel through which

Description example	Meanings	# of informants that provided this meaning in their description
"They say something about the artist and the environment where the music has been created."	Artist/Band Expression	9
"The best ones I sense as graphic poems."	The Album Message/Story	7
"If the album cover has more bright colors it tells me the music is more light..."	(Emotional) Representation of the Songs/Content	6
"Album covers mean forgotten faces, lost memories, and that we are growing old."	Cues for Memories	6
"If the album cover is ugly I would not buy it."	Aesthetic Art; Personal Identification	5
"They should have a relation with the songs."	Visual Representation of the Song	3
"Album covers are fun."	Fun; Enjoyable	3
"They gave me a feeling of what type of music I can expect."	Reflection of the Album Style/Genre	3
"I always look at the album cover to see if there has been enough care put into creating it. That says something about the quality of the work and whether I would buy it or not."	Trigger for Sales	3
"A good cover adds another layer to the album experience."	Another Layer to the Album Experience	2
"They protect the CD or LP."	Protection of the Recordings	1
"They help me navigate through my iTunes library."	Affording Navigation	1
"I like the lyrics so that I can sing with the music."	Container of Lyrics	1

Table 2. Summary of the album cover meaning descriptions from informants

artists can tell a story about themselves and/or their work. From the audience point of view however, the informants described album covers as a representation of the music and an aesthetic art form that when owned can be used to identify oneself towards other people and when seen serve as a cue for memories.

#### 4.2 Evolution of album cover meanings

This study was framed only around artifacts relating to 'audio storage' in order to focus on album covers. By audio storage we refer to techniques and formats used to store audio with the goal to reproduce the audio later using audio signal processing to something that resembles the original [24]. Due to this focus, the time scope of our study has been from 1870s up to 2006.

Table 3 provides a summary of our analysis of audio storage and their carried meanings. In total a number of 25 audio storage artifacts, categorized into 12 categories, were described for meanings. This resulted in a list of 7 meanings (Left hand column). These are: (1) 'Record Label Marketing', referring to the way that record companies used an album cover to market their brand; (2) 'Packaging & Protection of the Recordings', referring to the way in which album covers were a package for and protected the recordings; (3) 'Event Support', referring to what kind of role album covers played in supporting music events; (4) 'The Ability to Identify', referring to how album covers supported finding/recognizing music (from a collection); (5) 'Artist Branding', referring to the ways in which the artists branded themselves by means of album covers; (6)

'Compilation Albums' referring to ways in which a bundle of tracks known as an album came to existence; and finally (7) 'Self Artwork', referring to how album covers meant as a platform for personal expression for self made compilations for example.

In order to indicate how the artifacts carry and make these meanings available in culture for people, we have also provided an overview of meaning inscriptions for each category (Bottom left corner of the table). As an example for the category of the phonograph cylinder we can see that meaning (4) 'The Ability to Identify' for example, has evolved as following: phonograph cylinders were packaged and protected in cardboard tube boxes with printed logos of the record company on both the cardboard tube boxes and the cylinders themselves.

At first, phonograph cylinders could only be identified through a small paper insert with written information about the content of the phonograph cylinder, inside of the package. Later, people started to write this information on the labels by hand. This influenced the record labels to decide to stamp this information on the top lid of the phonograph cylinders. At a certain moment, the new packaging included a printed label on the lid, which could also be cut out to use for specific phonograph cylinder collection storage furniture. These early artifacts more or less initiated the rise of the first album cover that came out in 1909 [25].

Once the meanings of album covers were described from all relevant audio storage in the history of recorded music culture, we performed an analysis of how these meanings evolve over time. More specifically, we looked at the presence of meanings in culture related to the rise and endurance (existence) and discontinuation (sometimes perish) of some audio storage artifacts in time. Table 4 summarizes this analysis, which provides interesting insights. The evolution of meanings can one by one be explained as following:

**(1) Record Label Marketing:** The first audio storage artifact, the phonograph cylinder, was a technological invention by Thomas Alva Edison also known from the Edison Records. When analyzing the evolution of the 'Record Label Marketing' we see a decrease in the role of record labels, especially after the introduction of compact cassette, compact disc, and most influential of all, the MP3.

**(2) Packaging & Protection of Recordings:** The packaging and protection of recordings was a meaning present from the beginning of audio storage history, i.e. the phonograph cylinders, but became more and more present through the introduction of the 8-track in 1960, the compact cassette in 1963, and the compact disc in 1979. This meaning started to decrease in product form with the introduction of MP3 in 1995, which managed to dominate the compact disc as an audio storage artifact. Nowadays, this meaning, in product form, is only carried by digital content storage devices such as USB keys or compact discs, and to the extent that they exist, some other classical audio storage artifacts. This meaning however, has migrated from products form to online service forms like Myspace.

**(3) Event Support:** Events were probably one of the first places where music captured on audio storage was sold. While this already took place during the phonograph cylinder era, with the invention of gramophone record in 1895 and later the invention of the album cover in 1909, event support as a meaning started to increase its presence in culture. This increase of meaning presence was even more after the invention of vinyl records that became widely spread and popular in the society. Nowadays, album covers are still used to support events. They often even match event posters, tickets, etc. with regard to their visual identity.

**(4) The Ability to Identify:** Due to differences in packaging inherent to technological innovation this meaning has had ups and downs throughout the history. Record packaging for example, provided a much larger surface for album art compared to Phonograph Cylinders, compact cassettes, or compact discs. Vinyl records, due to a much better endurance than Gramophone Records, became more and more accessible for people and present in the culture. People have been using album covers for years to browse through music collections and identify music. Album covers have also been used as artifacts for self-expression towards other people. The dominance of compact cassette decreased the presence of this meaning from a 'higher' visual sense but the invention of compact disc and related artist booklets contributed to an increase of this meaning presence again. From 1995 on, when MP3 was invented, there has been a radical change in the inscription of identification, from a mainly

visual medium to a mainly textual medium. Inventions like cover flow introduced in 2006 by Apple Computers Inc., re-introduced some of the visual aspects of album covers in digital spaces [Cover Flow, 2006].

**(5) Artist Branding:** This meaning more or less came to existence after the invention of album cover in 1909. Later it increased presence due to the introduction of the vinyl records but really gained importance after the invention of the compact cassette and especially compact disc and related booklet. With the rise of Internet and invention of the MP3, artist branding started to migrate as a meaning from the compact disc booklets into artist websites and social media websites such as Myspace that focus on music [26]. Nowadays artist branding is almost an indispensable meaning in recorded music culture.

**(6) Compilation Albums:** The word compilation comes from the era that a couple of records were literary bound by an album. The invention of reel-to-reel and the increase of space for audio content on storages contributed to the creation of compiled albums with multiple songs.

**(7) Self Artwork:** The introduction of compact cassette in 1963 was the beginning of 'Self Artwork' as a meaning related to album covers. From then on people could easily record a compilation on a blank compact cassette, which had a template including boxes for writing down the tracks and a surface for artwork that could be created by people themselves. The introduction of the compact disc in 1979 continued to support this meaning presence along with the introduction of the MP3 in 1995. A couple of years after that though, 'Self Artwork' became less present as a meaning due to the decrease of tangible audio storage and an increase of digital audio storage formats that do not really support it. Nowadays people seldom create 'Self Artwork' for their digital music content and 'Self Artwork' has remained limited to tangible audio storages.

In general what we can learn from the analysis shown in table 4 is that both 'Record Label Marketing' and 'Packaging & Protection of Recordings' as meanings are becoming less present while 'Artist Branding', 'Compilation Albums', and 'Event Support' meanings of album covers are becoming more present in culture. 'Self Artwork' and 'The Ability to Identify' are also

interesting to look at since both of them are less present, probably inherent with 'Packaging & Protection of Recordings' since the audio storages of today have mainly been dominated by the MP3, which is a digital audio storage.

### 4.3 Designer's reflection

In this section we provide a summary of the designer's reflection based on the earlier results (Section 4.1 and 4.2). Looking at the rise of the album cover phenomena from the very beginning, brought us back to 1870s when the phonograph cylinder was introduced as the first audio storage artifact ever, that radically changed the culture of music experience. This radical innovation of meanings brought about change, which was both appreciated, and not appreciated at all by people during that time. A more positive received new meaning carried by phonograph cylinders was for example, the possibility that people could suddenly listen to music from the other side of the world without traveling to see a live event. A less positive received meaning carried by the phonograph cylinders was the separation of the music from its artist. In fact, back then, many artists were objecting to this meaning. When looking at the evolution of album cover meanings from a birds eye perspective what can be seen is that album covers came to existence due to the separation of artist from its music. In fact, the album cover throughout the years has become like a stage for the artist to somehow have a presence next to the recorded (and playing) music. The large Record covers, the compact cassette and the compact disc booklets, along with the ID3 tag of the MP3 and the Artist Website are all artifacts with inscriptions that support this meaning in various ways causing it to be sometimes more and sometimes less present in culture. This conclusion can also be triangulated with the conclusions of our informant meaning exploration study using social media, as 'Artist/ Brand Expression' was mentioned as a meaning of album covers by most informants. But what the album cover has also been throughout these years is a way for people (the audience) to display and browse through their collections in both individual and in social settings. This is however, is a meaning that has been less facilitated due to the digitalization of audio storage. Our current (2006) audio systems unfortunately are all based on text browsing and have neglected album covers; an artifact, which has been carrying many interesting meanings in

	1879s Phonograph Cylinder	1891 Gramophone Record	1929s Wire Recording	1948 Ear-to-ear Audio Tape Recording	1969s 8 track	1967 Compact Cassette	1979 Compact Disc	1981 AIFF	1991 MIDI	1995 MP3	1997 Last FM	2004 Cover Flow
<b>DESCRIBED MEANINGS</b>	<b>MEANING INSCRIPTIONS IN AUDIO STORAGE MEDIA</b>											
<b>Record Label Marketing</b>	Printed logo of the record company on the side, top and the cylinder	Printed logo of the record company on the sleeve and the record	Printed logo of the record company on the box and side	Printed logo of the record company on the cardboard box and side	Printed logo of the record company on the box	Printed logo of the record company on the box and booklet	Printed logo of the record company on the box, the disc, and the booklet	-	Printed logo of the record company on the box and the tape/disc	-	Digital logo of the record company on the website, online ads	Digital logo of the record company on the digital cover
<b>Packaging &amp; Protection of Recordings</b>	Cardboard tube	Cardboard sleeve	Cardboard box/vertical case	Cardboard box	Plastic box	Plastic box in box	Cardboard/plastic box	-	Plastic box in box	-	Cloud service	-
<b>Event Support</b>	For sale	Cover art posters, for sale	-	-	Cover art posters, for sale	Cover art posters, for sale	Cover art posters, for sale	-	-	Sample downloads	Sample streaming	-
<b>The Ability To Identify</b>	Small paper inserts with written info inside the package, written on the labels by hand, record label stamped on the top lid, printed labels on the lid	Printed textual and visual artwork on a big surface and on record stickers	Handwritten text on the packaging and side stickers	Handwritten text on the packaging and side stickers	Printed textual and visual artwork	Printed/handwritten textual and visual artwork	Printed textual and visual artwork	Digital text	Handwritten text	Digital text, digital covers, image, ID3	Digital text and artwork	Digital text and artwork
<b>Artist Branding</b>	-	Cover art	-	-	Cover art	Cover art, tape booklet	Cover art, of booklet	-	-	Digital text	Online ads	Cover art
<b>Compilation Albums</b>	-	Albums with multiple records	-	A tape with multiple recorded songs	A tape with multiple recorded songs	A tape with multiple recorded songs	A boxed disc with multiple songs	-	A tape/disc with multiple recorded songs	A directory with multiple audio files, long audio file with multiple songs	Playlists, playlist sharing	A folder with multiple songs
<b>Self Artwork</b>	-	-	-	-	-	Blank tapes, templates	Blank discs with templates	A directory with multiple audio files	Blank tapes/ discs with templates surface	Digital templates	-	-

Table 3. Audio storage, the described meanings, and their inscriptions per category

the culture of music experience. Moreover, an artifact of which its development (meaning innovation) has not been utilized yet.

In sum, we can say that the meaning of album covers on a more deep level, i.e. a conclusion based on an analysis

of over a century and three decades, actually is 'a medium that affords interaction between the artist and the audience'. What if, we can envision a future audio system that is designed based on this understanding? In the following section we present NAVA, a home audio system that we designed based on this vision.

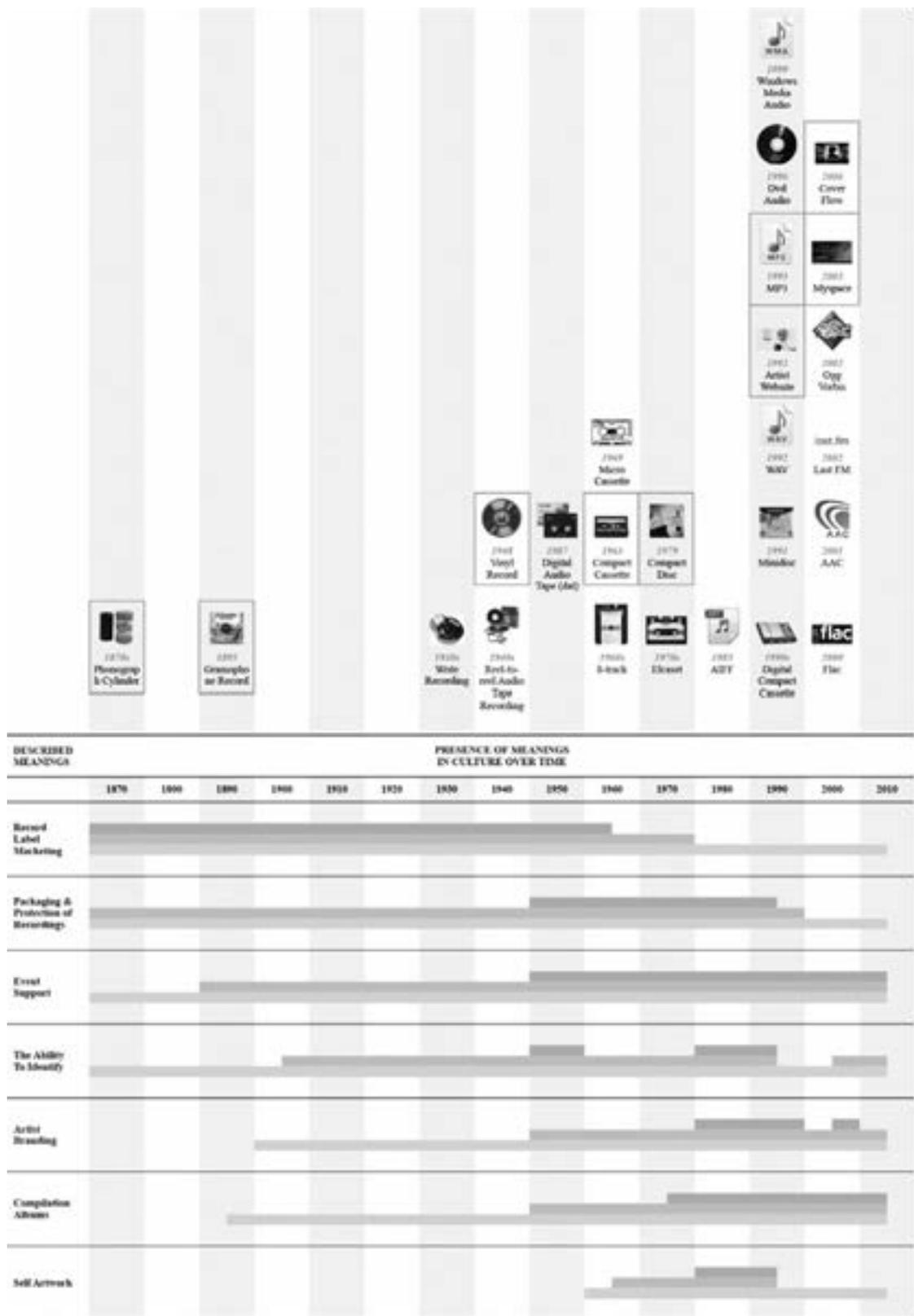


Table 4. Album cover evolution and described meanings.

High intensity green = more present. Low intensity green = less present. Green frame = influential artifact.

#### 4.4 Design-driven innovation: interactive album covers

In this section we first introduce a radical home audio system, which was designed based on the evolution of recorded music culture meanings. In specific, we introduce two design-driven innovations (radical meaning innovations) for album covers, integrated in this system. Both innovations were driven by our study of the evolution of album cover meanings.

What follows is a presentation of the results by answering the 'why' and 'what' questions based on our evolution study. The 'how' question, i.e. how the meanings were inscribed, will not be discussed in the present paper.

NAVA (in Farsi 'nava' means tone/tune; it is also a principal mode of Iranian traditional music) is a home audio system in the form of a coffee table. Digital (music) content can be uploaded wirelessly and displayed on the NAVA, which provides an inviting interaction that affords a social music experience (Figure 2).

This then newly designed home audio system was quite radical for its time, and to some extent, can still be considered radical innovation of meanings (Figure 1). Below we describe two new meanings that we introduced in the NAVA social music table. Both of these meanings are related to album cover meanings:

(1) Intuitive multi-user digital music browsing and playing: The NAVA is designed in such a way that more than one user can operate it. Moreover, it allows for multi user-, and therefore social-, interaction. The NAVA allows for a rich visual and almost tangible interaction with digital (music) content. People can sit around the NAVA and experience music on different levels by interacting with the digital (music) content on its touch screen display. (Figure 3). Furthermore, people can share their digital (music) content with others by uploading it to the NAVA where it can be browsed and played intuitively, and experienced socially.

(2) Interactive album covers for music context experience: Next to digital music content (digital audio), music context (information that one used to find in CD booklets and can now find on the Internet)



Figure 2. The NAVA social home audio system (left); QR code for a video of the NAVA (right)



Figure 3. Example of a dynamic and interactive album cover: 50 Cent interactive album cover (left); The NAVA's multi-user interface (right)

is represented by means of dynamic and interactive album covers. This enables fans to stay in touch and up to date with the artists, and artists to regularly express themselves and interact with their audience. Since the album or track content with regards to both music content and music context is dynamic and changing, the experience is always unique (Figure 3).

Both meanings are based on innovating the meaning of album covers from physical or digital static artwork, which is designed, sometimes printed, and sold, to digital and dynamic artwork which can continuously change and be updated from the artist side and interacted with from the audience side providing services since the NAVA social music table is connected to the internet. Although Apple Computer Inc. has introduced 'Cover Flow' in 2006 and Microsoft Inc. has introduced the 'Surface Table' in 2007, this is a meaning innovation, which is to date (2013) a potential radical innovation of meaning for the recorded music culture or more specific the home audio system market [25, 27].

## 5 Conclusion and discussion

We have shown how meanings of a product/service can more deeply and thoroughly be understood. This was done using script analysis theory to describe meanings from predecessor artifacts evolved over time and through a meaning evolution exploration in which one can investigate how the presence of meanings carried by artifact in a certain culture changes inherently with those artifacts over time.

Also supported by our previous work [9], we conclude that the discovery of these more deep and thorough meanings can support a more radical and purposeful design-driven innovation strategy: (1) One could easier select which existing meanings to preserve, re-introduce, or dispose; and (2) Which new meaning to introduce next to the existing meanings in such a way that one creates design-driven innovations that are truly sustainable (in the sense of people, planet, and profit; i.e. innovations that develop our culture and society) and have a higher chance of adoption [9].

A weakness of our current research approach is that the description and analysis of album cover meanings evolution was only done by one person, the first author of this paper. The social media meaning exploration study shows that such description and analysis studies can benefit from a more holistic approach. The reason for this is twofold: First, the meaning description and meaning evolution analysis can be done by more than one person and preferably through the involvement of actors or interpreters related to the target culture for innovation. Multiple expert perspectives can enrich the study and increase its quality [30, 31]. Besides, sometimes a one-man job is not even possible due to the complexity of the project and/or lack of expertise in a certain project context (target culture for innovation) [31]. Second, one should not forget that all actants, human or non-human (artifacts), are entangled in the world [32]. Moreover, they form a sociocultural regime that one could see as a products service system or ecosystem. This stance, i.e. knowing that an artifact is part of a bigger landscape, could have a significant change of how the meanings of an artifact could be defined and perceived [33, 34].

## 6 Future Work

We plan to continue our research by exploring how meanings can be described and inscribed from

a product service system perspective. Moreover, how designers can work in co-operation with interpreters (human actors who can contribute to the meaning, description, creation, inscription, and realization of design outcomes) during early developmental stages of projects to benefit from objectivity and their resources for operationalizing innovation concepts.

While our focus within this paper has been more on the meta level and from an innovation design strategy perspective, we would also like to explore how existing and new meanings can be inscribed into products/services. Moreover, in this paper we have focused on the 'what' and 'why' questions regarding meanings (which meanings and why) while we can also focus on the 'how' question regarding meanings (how can radical new meanings be inscribed with combination of existing and past meanings) [28, 9].

Furthermore, we believe that our approach of investigating the overall established meanings of a product, service, or phenomena in the here and now as a result of history and evolution, also has potential for dealing with societal challenges a.k.a. wicked problems (e.g. aging). Therefore, we are pondering how this approach can be used for addressing societal challenges and also used for the development of phenomena in sociocultural regimes.

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# Getting a GRIP at the Design of a Nature Inspired Relaxation Space for Work-Related Stress

## Abstract

This paper presents the work that has been conducted as part of the GRIP project about work-related stress in combination with the nature inspired design consortium. After 1,5 years of extensive research on the GRIP project including contextual user research, gathering stress insights through probes and data visualisation, and co-creation with stress experts and employees, it was finally decided to design an ambient space that enables employees to relax. The design of the relaxation space was inspired by nature and offers employees an adaptive environment that reacts to their presence by creating a personal environment, varying in size, soundscape and animated light. The environment stimulates paced breathing, meditation and helps employees to become more aware and in control of their personal response to stressors and relaxation. The design has been evaluated by 23 experts on the basis of one time use of the space. The expert evaluations resulted in very positive responses regarding the low effort required and the high quality of the relaxation experience provided. We are currently collecting feedback from employees taking part in a prolonged end user evaluation to explore the value of small adaptations in our design in order to further improve the relaxation experience.

## 1 Introduction

The work described in this paper is conducted in light of two collaborations, namely the GRIP project, and the Nature Inspired Design consortium, and aims to address work-related stress through design. In this section first relevant background information about the project collaborations will be provided, followed by a short introduction to the domain of work-related stress, and the peculiarities that need to be considered when designing within this domain.

### 1.1 Project collaborations

The Dutch government funded the GRIP project, as part of a larger program (CRISP) focusing on the design of Product Service Systems (PSS). The aim of CRISP is to develop new markets for the creative industry by stimulating research on the role of design in industry. GRIP deals with flexibility versus control in the design of PSS for work-related stress (Badke-Schaub & Snelders, 2011). The GRIP project is a collaboration between Philips Design Innovation, the Design Academy Eindhoven, and TU Delft and Eindhoven University of Technology. GRIP starts from the premise that in the case of PSS, the control of designers over processes and outcomes is reduced.

The Nature Inspired Design Consortium unites multiple companies, among which are Philips and Interface, and the Industrial Design department of the TU Delft in

performing research on the practice of Nature Inspired Design (NID). The aim of the consortium is to come to better and proven effective NID methods. Design inspiration through nature can take various forms such as biomimicry or Life's Principles. Biomimicry can be defined as imitating or taking inspiration from nature's forms and processes to solve problems for humans (Benyus, 1997). Life's principles are successful principles of nature that provide the parameters, conditions, and requirements to function more sustainably. Life's Principles can be used to develop self-sustaining ventures and technologies that, like nature, maximize benefits with minimal effort and negative impact." (Patel & Mehta, 2011).

This paper presents our experiences within the GRIP project and the Nature Inspired Design Consortium, and discusses the development of a nature inspired prototype, namely a relaxation space. The relaxation space offers a platform for designers and service providers to create new PSS in the future.

### 1.2 Work-related stress

The concept of stress has been introduced first by Hans Selye who defined stress as a non-specific response of the organism to any pressure or demand (Selye, 1956). Later, Selye (1974) made a distinction between eustress and distress. If an effective coping strategy can be found, and if the necessary resources are present, this will result in positive stress, called Eustress. This state of positive stress brings an individual in an optimum state to perform. When the individual is not able to cope effectively the stress becomes chronic and the individual will experience distress (Selye, 1974). The influence of the environment on the evaluation of stress is pointed out by Lazarus & Folkman who define stress as: "a particular relationship between a person and the environment that is appraised by the person as taxing or exceeding his or her resource and endangering his or her wellbeing" (Lazarus & Folkman, 1984).

Some literature targets work-related stress in particular. Le Blanc et al. (2003) identified the main stressors occurring in an office environment and divided them in the following four categories: job content, working conditions, employment conditions and social relations at work. Job content includes among others work overload, complex or monotonous work, excess

of responsibilities, conflicting/ambiguous demands. Working conditions include factors such as noise, vibrations, lighting, temperature, posture, or lack of protective devices. Employment conditions include shift work, low wage, poor career perspective, job flexibility/insecurity. Social relations at work include poor leadership, low social support, liberties, and discrimination Le Blanc et al. (2003). A model that explains the experienced pressure from work is the job demands and job resources model (Bakker et al., 2004). Job demands refer to physical, psychological, social or organizational aspects of the job that require physical or psychological effort and costs (e.g., work pressure, role overload, emotional demands, and poor environment conditions). Job resources refer to physical, psychological, social or organizational aspects of the job that are functional in achieving work goals, reduce job demands and the associated physiological and psychological cost, or stimulate personal growth and development.

Stress or tension can be effective and healthy, and may help you to perform better, for example when giving a presentation. However, stress can become ineffective and harmful if it continues over a prolonged period of time (Petri & Bouman, 2009). Without sufficient moments of relaxation to release tension, the stress will build up over time. "If you push your body by constantly being in an alert state and do not give it a chance to recover, a time may come when you won't be able to continue" (Petri & Bouman, 2009). In this paper we explore various design directions and opportunities that could help working people to balance between an alert state and recovery.

### 1.3 Designing for work-related stress

One of the roles of designers is to think about the relationship between human and technology and to designate it: give meaning to it (Krippendorff, 1989; Verganti, 2009). Thus, the role of the designer is to give new meaning to technology. While technology has the capability to expand upon the possibilities of human beings, this is not achieved in a neutral way. Technology changes human perception.

Krippendorff & Butter (1984) indicate that designers can demystify complex technology, improve the interaction between artifacts and their users, and enhance oppor-

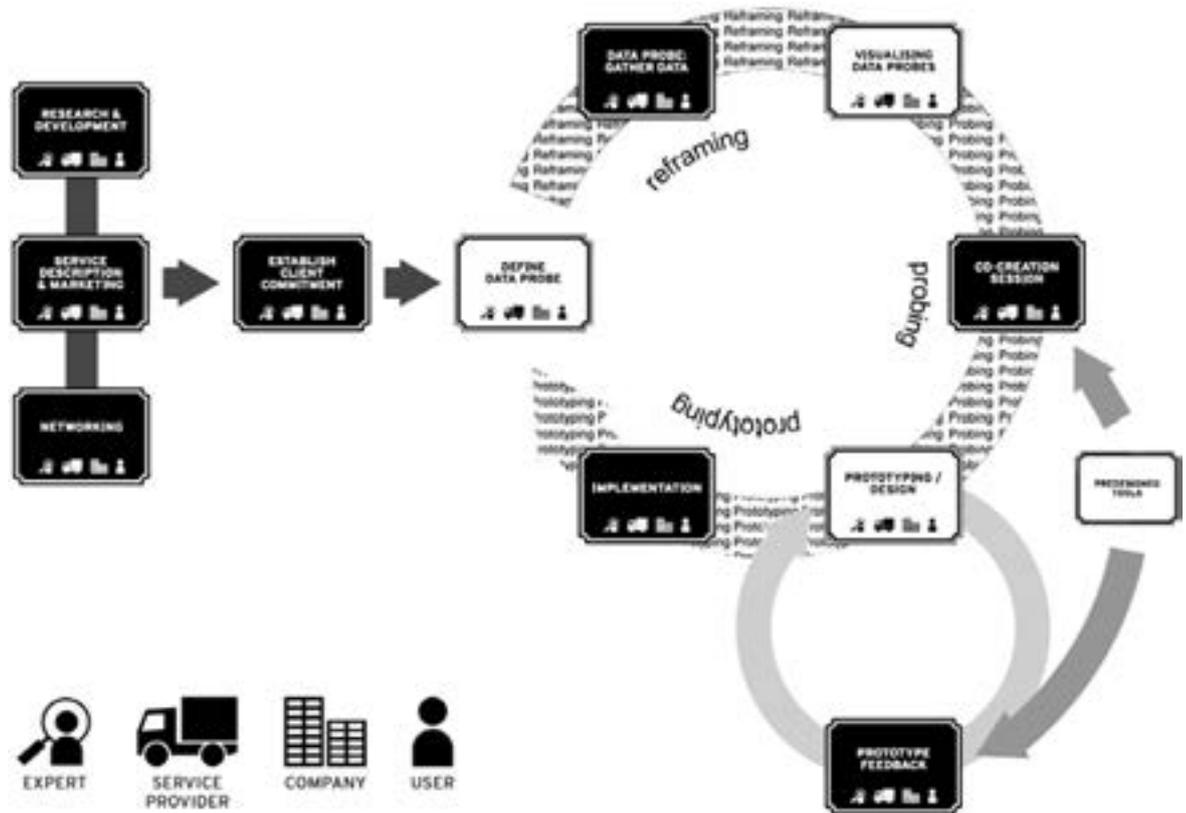


Fig. 1. GRIP Service Model v6, designers (white) and all stakeholders (black) alternate in taking up a central role in 3 different stages: design for analysis (reframing), design for research (probing), design for support (prototyping)

tunities for self-expression through product semantics. Meanings emerge in human interaction with objects (Krippendorff & Butter, 1984). By formulating ideas about the object, and cognitively placing it into (real or imagined) contexts, people allow themselves to formulate an understanding of the object, or in other words: "Meaning is a cognitively constructed relationship" (Krippendorff, 1989)

The role of the designer is different for PSS design compared to traditional product design (see also Rajmakers et al., 2012; Van de Garde-Perik et al., 2013). In PSS development multiple stakeholders can play a role and each can offer different values to the PSS development. In our project targeting work-related stress PSS, we discovered already at the start that there were a large number of stress combating or relaxation techniques that were available through various channels (books, websites) and service providers (psychologist, mindfulness therapists, wellness resorts).

One of the first activities within the GRIP project was an expert day where industry stress experts with backgrounds in psychology, technology and occupational health, and a worker with experience of burnout met with designers to discuss and explore the topic of stress at work. Furthermore it enabled us to gain and share knowledge with industry professionals, and to start building a network of expertise. The invited

stress experts indicated that there is currently a lack of accessible tools that visualise the effects of stress. Thus, many of these existing techniques lack the use of technology, while Philips had the opportunity to make use of various technologies to monitor human physiological processes. The main conclusion of the expert day was that people need to be aware of their body signals or stress levels, but also need to be motivated, in control, responsible, and active to deal with stress. In addition, it became apparent that there is a strong taboo on discussing stress at work, and that the image of stress might be in need of 'rebranding'. Therefore, within this project we took an open innovation approach together with various experts and explored the potential of a combination between existing stress techniques, and state of the art technology, while using research and design expertise.

## 2 Choosing a design direction for work-related stress

Before choosing a final direction for our nature inspired design prototype we performed contextual research into work-related stress. The three stages of the GRIP service model were followed in this process: reframing, probing and prototyping (See Fig. 1; For a more detailed description see Rajmakers et al., 2012; Van de Garde-Perik et al., 2013).

## 2.1 Reframing work related stress

Currently, many organizations feel more responsibility to take care of their employees, e.g. to lower burnout rate, to let people perform optimally, to take care of employee well being. Within the GRIP project, we partnered with a mental health care institution in Eindhoven (GGZE), to co-develop a PSS targeting work-related stress. We chose for a mental healthcare organization because we learned from the expert day that especially employees in a caring job such as in health care or education tend to take up more work than they can deal with or find it hard to say no in their job, because they are working with people who need their help (mental health clients, or students). Besides, the GGZE is particularly open to employee wellbeing, because of their Planetree vision that good healthcare can only be provided through by a healthy organization (for more information, see <http://planetree.org/>).

As a first step in getting familiar with the GGZE organisation and work routines, we observed and interviewed health care workers in their own environment to spot potential problems or causes of stress that we could target and monitor. As designers we wanted to better understand their work pressure and stressors, and understand the differences between various approaches or strategies that employees have regarding work-life balance and stress relief. It was agreed with the department of Ambulant Care that we could shadow several GGZE employees during a working day to observe the overall organisation's culture of stress. Furthermore, we collected more stress insights by having employees monitor their work patterns through three different stress data collection probes: a manual registration of breathing patterns, a GRIP-booklet to collect various stress measurements, and a public relaxation measure.

Firstly, the manual registration of breathing pattern was inspired through different channels, for example by various expert presentations, existing technologies such as emWave (<http://www.heartmathstore.com/>), stresseraser (<http://stresseraser.com/>), and the book by O'Hare & Blase (2010). Participants were asked to register their breathing for a period of 2 minutes by drawing a wave pattern on a paper roll (see Fig 2). Secondly, the GRIP-booklet of stress measurements was inspired by diaries as often used in cultural probes

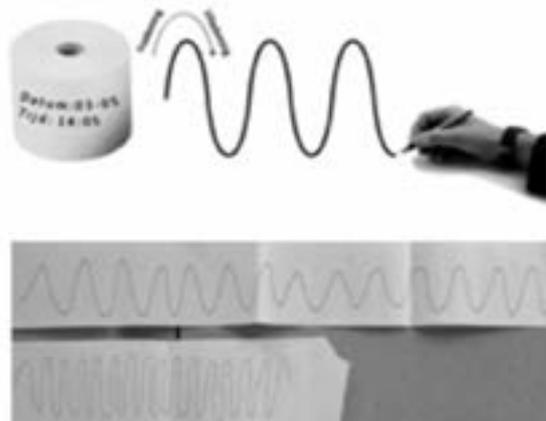


Fig. 2. One of the probes used to collect stress insights via breathing patterns. Instruction (top) and samples (bottom) of manual breathing registration on paper (upwards line when inhaling, downwards when exhaling).

studies (Mattelmäki, 2006). Each page of the GRIP booklet consisted of a number of fields where the following data could be entered: date and time of the registration, a comment field, the Self-Assessment Manikin (Bradley & Lang, 1994: positive-negative valence, high-low arousal and low-high dominance), the six item State Trait Anxiety Index, and a field to enter the result of the Azumio Stress Check (<http://www.azumio.com/apps/stress-check/>). Thirdly, the public relaxation measure asked questions concerning relaxation and break taking behavior at work. The relaxation measure encompassed reading a question and giving an answer by putting an ice stick in the appropriate vase (see Fig. 3).

Multiple workshops were organised with researchers, designers, GGZE employees and managers, as well as stress experts to discuss and visualize work-related stress from various perspectives. Together we discovered large individual differences between employees; in terms of work strategy and perceived obstacles/difficulties, in preferences regarding the use of particular data probes, but also in actual stress measurements (i.e. level of stress). For some people the mere reflection on the personal situation was sufficient, whereas others were in need of the data being visualised and interpreted for them. Some people indicated to want evidence of the data probe before using it, whereas others were open to using it without any



Fig. 3. One of the three probes used to collect stress insights on break taking behavior, namely the public relaxation measure used in canteen of GGZE.



Fig. 5. Example Paced Breathing: Rhythm Pad 3D render (top) and prototype (bottom) including feedback on Heart Rate Variability – TU/e student project by Sergej Lojko



Fig. 4. Example Personal Balance: Reco, smartphone relaxation coach app – TU/e student project by Christoph Lukkien

evidence or explanation. It became clear that extreme scores and deviations are potentially interesting and easy to investigate in more detail. Furthermore, in order for self-assessment to become successful there needs to be motivation, but also some sort of routine (i.e. xed times during the day; every time you return to your desk, at the start of a team meeting). The environment was another important factor that turned out to have an influence on perceived work load (i.e. different locations of the GGZE were perceived differently; open plan offices resulted in most disturbances from visitors or noisy colleagues).

## 2.2 Probing work-related stress solutions

More than 50 ideas and probes targeting work-related stress were developed on the basis of data visualization and co-creation events with all stakeholders involved. After receiving feedback from stress experts and GGZE employees these ideas were eventually reduced to 3 directions for prototypes of work-related stress solutions: Personal Balance, Paced Breathing and Ambient Experience (see Figures 4-6). Over 25 prototypes have been made in total, both by students of Eindhoven University of Technology and by Philips Design Innovation. Below, we present a selection of these prototypes, aimed at making work-related stress less of a taboo topic for people, encouraging people to treat stress in a more lighthearted fashion, while respecting that people differ in what might help them. Note that there are overlapping elements between the prototypes, since all of them require monitoring some kind of parameter (physiological stress levels, consecutive working times, keyboard hits, emotions etc.).

The Personal Balance solutions aim to help people by providing insight into this measured parameter (an example is shown in Figure 4). This is a personal well-being solution that helps a person to see their daily stress and the way they cope with it. By giving feedback of previous stress events and the current stress level, a person gets motivated to recuperate, by going for a walk, or relaxing for a while.



Fig. 6. Example Ambient Experience: Initial concept sketch and prototype (left). Zen Pebble, Intelligent Aroma Diffuser. Emotion detecting software is used to release aroma at an appropriate moment through Zen Pebbles (right) – TU/e student project by Sherry Hui Wang

The Paced Breathing solutions are centred on helping people to regulate their breathing rhythm and consequently to influence other relevant parameters (see Figure 5 for an example). Paced breathing is intended to re-establish an optimal connection between the mind and the body. People are sometimes not aware of their mental state while at work. As tension goes up, the head is overflowing with things that need attention or require decision-making. People get disconnected from thoughts, feelings and bodily responses, and unaware of their well-being.

Finally, the Ambient Experience solutions are based on reactive environments that provide a more public (and thus social) type of feedback to people (see Figure 6). By tickling the senses and offering different types of mental triggers, an environment can stimulate you to become more aware of your body and mind. Subtle fragrances, sounds, haptics and visuals can be (sub)conscious cues for people in the environment to take a moment for themselves, and nudge people into different norms and values about relaxation at work.

### 2.3 Co-creating a work-related stress solution

We intended to build and evaluate a nature inspired prototype for work-related stress that is informed by insights from all three directions at Philips Design Innovation, in collaboration with multiple experts.

This means that experts in various domains are actively involved in the design process, and give intermediate feedback to our design decisions and input for future decisions. As such, Philips has chosen a flexible approach for the development of the prototype, based on the experiences in the GRIP project and the NID consortium. The final design activities of Philips Design Innovation are a powerful push towards re-branding the notion of work-related stress, following some of the probing directions we discussed above.

The project's aim of the prototype building was to generate expert and user feedback. The purpose of the actual design was to help people to cope with work-related stress during work time, both as prevention of stress building up and treatment of existing stress. Furthermore, we wished to place the demonstrator in a public space to raise awareness regarding the topic of stress, and hopefully to change group dynamics within the workplace. Therefore, the space should build on the strengths of nature, yet fit into the working environment. It should be an accepted and attractive place to retreat oneself during work time, it should not be stigmatizing in any way but inviting by its appearance.

A pressure cooker was conducted to build further on the experiences in the GRIP project and the NID consortium. Within this pressure cooker we generated more detailed ideas for our relaxation space, created a rough first prototype and applied body storming as a means to explore various use scenarios and obtain quick feedback from Philips employees. From this pressure cooker we learned among others that the space should allow oneself to be shielded of from the work place

and provide a safe and private environment that would suit both individual and group use. The insights from the pressure cooker were later complemented with additional internal research and employee interviews within Philips Design Innovation.

Originally the idea was to have two related prototypes, namely one prototype at people's workplace to trigger people to take a break. And the other prototype would be the place where people can go to have their break, a relaxing session or a peaceful moment away from the usual work place and activities. However, after long deliberation it was decided to offer a communal experience instead of a personal treatment. A personal measurement or trigger to go to the relaxation space, could lead to stigmatizing people (being too stressed or incapable of managing your work), or even resulting in people avoiding to use the triggering function (e.g. such as frequently happens after installing RSI software). Therefore, the personal stress measurement or trigger, was not incorporated in the final design. Instead, we aimed to increase awareness within the community regarding the need for healthy and balanced working behaviour by intrinsically motivating people and encouraging positive social support among colleagues within the working environment.

The prototype of the relaxation space had to be built within two months and should fit to the context and employees of the Philips Design building at the High Tech Campus in Eindhoven. The design of the space would be a nature inspired ambient environment, supporting individuals and groups of people to regain their personal balance. Besides, it should support several relaxation techniques, such as paced breathing, mindfulness, meditation, regaining energy, and power napping. In order to achieve these qualities, a mix between technology (mainly lights, sound, enclosing curtains) and natural aspects (materials, feeling of a natural environment, aroma therapy etc.) was strived for.

In our design of the relaxation space we wanted to build on existing knowledge in the field of stress, as well as rely on nature's qualities (see Figure 7). Nature has a high level of attraction to people, it offers many experiences through various senses, and it has relaxing qualities for people even though we have limited control over it (e.g. we cannot control the weather).



Fig. 7. Inspiration from nature and design

Nevertheless, we can have some control over our experience in nature by choosing when, where and how to go (e.g. winter or summer, forest or seaside, alone or with others). Taking into account the fact that people who suffer from negative stress have difficulties making decisions, we wanted to create a similar yet different experience to nature with our relaxation space. The relaxation space should offer always changing experiences, have a relaxing quality yet offer limited control. Thus, as in biomimicry and in line with Life's principles we wanted to take inspiration from nature's forms and processes to enable people to easily balance relaxation and work; maximizing the benefits for employees with minimal effort. The aim was to create an ambient environment that will help people to feel at ease, and let go of some control.

The relaxation space could be considered as a gateway from the work environment into a different world, with the following features:

- It should be a welcoming space with an inviting ambiance, appealing to people's curiosity. The space should appear to be alive and inviting even if nobody is using it (like with nature there is always activity which could potentially catch someone's attention).

- Physically away from the work space-environment but still be nearby/out of sight from working people to provide a shield from the open office working environment.
- It should offer a relaxing, calming experience through intuitive interaction, and provide focus and breathing guidance through enclosure, music therapy and chromo therapy (in max. 15 min.)
- The space should enable people to tune the experience to their own preferences and strategies for relaxation in an easy way (e.g. individual vs. group use, size of space, moment of day, position)

### 3 Implementation & evaluation of a relaxation space

To enhance choosing the final design direction for the relaxation space three different scale models were built. Then, both a full scale paper prototype and a working prototype of the relaxation space were developed. Each of these stages will be discussed below.

#### 3.1 Prototyping a relaxation space

After building three different scale models, the rough set up of the final design was chosen (see scale model in Figure 8). The final design would be a relaxation space that was shielded of from the environment through curtains that could move separately from one another to adapt the size of the space to the number of inhabitants. The original scale model was designed as 4 by 4 cells, allowing many different configurations (e.g. 4 single cell configurations, 2 simultaneously used 2\*2 configurations, a 3\*3 and single cell configuration). The next intermediate stage, was a low-fidelity prototype that was built in the basement of the Philips Design building (see Figure 9). The paper prototype consisted of just 2 cells, and had paper curtains, a computer to provide sound experience, and one single light source from the ceiling above each cell. Nevertheless, the paper prototype enabled us and invited experts to experience what being in the relaxation space could be like. Both the scale model and the low-fidelity prototype were presented to experts in the stress domain, to get intermediate feedback regarding our design.

We arranged meetings with various experts and made visits to 2 location of the GGZE where special attention is put into the design of rooms and buildings to make clients feel at ease. These visits and meetings



Fig. 8. Small scale model for relaxation space (4\*4 cells)



Fig. 9. Full scale low-fidelity prototype of relaxation space (1\*2 cells)

served as a great inspiration to our design process. For example, we discovered that many experts we have consulted use nature in their treatments in some form (e.g. use of images, or going for a walk outside in nature). The overall sensation of nature around oneself can help to achieve a positive result (i.e. changing in space, differences in temperature, wind, smells, etc.). According to our experts nature works calming, but it can also give problems (e.g. if you don't like certain weather types; or if you suffer from winter depression, spring exhaustion, or allergies). Therefore, we needed to decide how closely we wanted to get inspired through nature. Taking into account all feedback and insights obtained so far, we decided to create an indoor space with the strength of nature, yet fitted to an office environment. As such, we wanted to create a space with its own specific qualities next to having the opportunity to go out in the real nature. As in real nature, the relaxation space should offer a rich, multisensory experience, with a rhythm of its own (daily or seasonal).

Furthermore, it was important that we provided a space that is not work-related (to enable people to step out of the work context). A cozy environment or the feeling of safety can be truly important. Also, having the feeling of owning a particular spot, or having control over the situation are influencing factors that can make people change their mind. Furthermore, in the research phase we have seen that people sometime feel the lack of control over their working environment (especially in open plan work spaces).

Also the posture during meditation and relaxation is very important; you should not be distracted by physical discomfort. People are not supposed to fall asleep when meditating, but that one should stay alert, while mind and body should be relaxed. Following specific indications can help people to stop their mind from working. This is a skill that can be trained. Once you know how to do it, you can do it without help. Furthermore, from stress experts we learned that relaxation is personal; what works for someone may not work for another.

### 3.2 Full scale Implementation

Because of restrictions in the amount of available time and resources, it was decided to build a smaller configuration for our working prototype than the

original 4\*4 configuration. The smaller configuration allowed fewer possibilities for simultaneous use of the relaxation space, but still it allowed us to explore the overall concept underlying the space. The final relaxation space is a configuration of 2\*2 cells, with Interface flooring, 12 curtains allowing the separation of the 4 different quadrants, a ceiling with 16 individual light sources, and an ambient soundscape.

Initially, the relaxation space invites passers by to come in through the attraction of a white pulsating light coming from the ceiling. Once people enter the space, the relaxation space responds to people's presence. The curtains lower, the soundscape is being generated, and the lights turn into a colored spectrum. Depending on people's preferences they can either sit down or lay down, using the comfortable repositional cushions provided with the space. Besides the ceiling light, also light objects could be used inside the space to create a different dynamic to the space. People have implicit control over the relaxation space. The curtains automatically adapt to people's position within the space. In addition, people can choose to bring in furniture or light objects to further adapt the space to their own relaxation preferences.

The relaxation space has been evaluated by 23 experts from various fields (see Figure 10), i.e. ambient experience design, interaction design, relaxation (service providers & researchers). This evaluation proved that the space is very well suitable to speed up the relaxation process. People experienced with yoga and meditation indicated the relaxation space enables them to get an even quicker experience than when relying on traditional yoga and meditation procedures. People with less experience in relaxation (e.g. interaction designers), did not really try to use the space for their own benefit, but stated on the basis of exploring the relaxation space that "It could work". Perhaps the context of the expert evaluation (they were asked to professionally evaluate the relaxation space in the presence of a designer and design researcher) did not fully enable them to use the space for relaxation purposes. Therefore, in the next stage of evaluation more emphasis was put on the need for users to surrender to the space. The relaxation space does not provide a magical cure to stress, but people need to play and an active role (as was already discovered during the first expert day).



Fig. 10. Individual use of relaxation space occurred in expert evaluations and prolonged user evaluation



Fig. 11. Shared use of relaxation space for meditation purposes

Currently, we are further investigating the meaning of the relaxation space for employees from Philips Design over a prolonged period of interaction, namely three weeks. Simultaneously, we are exploring small adaptations in our design to improve the relaxation experience for users. While the investigation is not yet completed, we can already see that different use

situations and meanings of the relaxation space emerged over time. For example, some people made use of the relaxation space to get out of sight of colleagues and enjoy a moment for oneself (see Figure 10), while there were also large groups of people that used the relaxation space during lunch time for a group meditation with approximately 20 people (see Figure 11). The pace of the lights suggests a breathing rhythm to users and can provide support in paying attention to one's breathing pace. The soundscape is generally appreciated and supports the relaxation experience (e.g., "the sounds are soft and contribute to thinking less and feeling/ experiencing more"). Furthermore, based on positive responses from various industries it could be that (some parts of) our design become of meaning in different application areas e.g. mental healthcare, or hospitals.

#### 4 Conclusion

This paper illustrates how open innovation together with multiple experts can be achieved in a relatively new area for design (i.e. the field of work-related stress). Our open and flexible approach has proven beneficial to all stakeholders involved in PSS design. Furthermore, the adaptive environment enables multiple forms of interaction and hence can carry different meanings depending on its use.

We have discovered that the relaxation space that was designed, implemented in an office environment and evaluated enables people to let go of control and allows them to open up to a relaxing experience. People who already practice yoga or meditation indicate that they are capable to achieve a quicker and deeper effect by being in the relaxation space.

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# Robots in the Theatre and the Media

## Abstract

Robots frequently feature in the movies and occasionally in the theatre. Their presence in the media is of major importance on how users interact with them. Due to the scarcity of robots in everyday life, most of the users' expectations and interpretations about robots stem from the media. This paper provides a framework of robots in the media that will help robot interaction designers to assess preconceptions about robots.

## Keywords

Robots, HRI, media, theatre

## 1 Introduction

Robots have triggered the imaginations of writers and directors for many years. Robots have been featured in all types of artistic expressions, such as books, movies, theatre plays and computer games. The importance of the media in forming our understanding of the world cannot be underestimated, in particular in situations in which access to real experience is limited. We are at an interesting point in time where on the one hand more and more robots enter our everyday lives, but on the other hand, almost all our knowledge about robots stems from the media. This tension between the expectations fuelled from SciFi and the actual abilities of the robots can result in negative experiences. It is therefore important for us to know about how the media has portrayed robots.

We would like to focus on robots being used in the theatre since they better represent the current state of robotics. Computer graphics can nowadays visualize almost anything and hence depiction of robots in movies can be more fantastic. Movies can show us robots that use anti gravity to float around, but there is little use for such a vision for the actual future of robotics. Robots that have to work on stage are constrained to the current state of the art in robotics and are therefore closer to what robots will be like in the close future. While this form of real-time acting introduces a healthy dose of reality, it also constrains the distribution of the performance. The audience needs to be present in the theatre to experience a play. This temporal and physical constraint of the performance limits the number of people able to see the show. Movies, on the other hand, can be distributed on disks or through the internet and can be viewed at home at any desired moment. Theatre plays are, as a matter of fact, often video-recorded to document the event and to make the play available for review, discussion and debate. We believe that although the theatre is the preferred source for our study, we need to expand it to include movies and other media since far more people will have seen a movie with a robot than a theatre play with one.

In the field of HRI, there has also been a long discussion on whether video recordings of robots can be used as a replacement for live human-robot interaction. While

Woods et al argued that the two interaction styles were broadly equivalent [1], Bainbridge et al concluded that participants had a more positive experience interacting with robots than with a video representation [2]. Powers et al also found large attitudinal differences between participants interacting with a collocated robot in comparison to a remote robot [3]. These results strengthen the importance of considering robots in the theatre over robots appearing in movies.

We have to acknowledge that it was not possible for us to consider every robot mentioned in every book, film, computer game or theatre play. Their number vastly exceeds our limited capacity for processing. But an exhaustive review is, in our view, not even necessary. We believe that we can still draw some valid conclusions from a representative sample of robots in the media. We also do not claim that any of the conclusions drawn in this paper are scientifically valid by the standards of the natural sciences. We are filtering and interpreting the available data and we cannot exclude the possibility that our personal knowledge and experience biases the results. But we shall not shy away from the task because of this limitation. Most of the work in the humanities relies on interpretation and the arguments we bring forward are hopefully still of interest to the HRI community. Cynthia Breazeal has already argued that theatre is an interesting test bed for HRI [4].

The goal of this paper is to reflect on how robots have been portrayed in the media, which leads us into a definition of a framework to describe common patterns of human-robot interaction in the media, and this in turn gives us clues on the expectations that future users have towards their robots.

## 2 HRI as theatre

The research field of human-robot interaction (HRI) investigates how humans and robots interact with each other. This multidisciplinary field includes three large sub fields. Firstly, it includes the developments of robotic technology that are targeted to be useful for the interaction. Secondly, it includes a creative field in which daring new ideas are explored and artistic installations are developed. Lastly, it includes studies that are targeted at understanding human reaction towards robots. For this purpose, experiments are

conducted in which robots act in front of human users, as not all actions of a robot can be produced as a result of computations. Due to the limitations of artificial intelligence, researchers often have to fall back on the Wizard-of-Oz method. In this method, an experimenter observes the interaction from a hidden location and remotely controls the robot accordingly. This is a mild form of deception, since it allows the robot to appear more intelligent than it really is. More elaborate deceptions are occasionally necessary to test certain aspects of HRI, such as the study of embarrassment [5] or of the users' hesitation to kill a robot [6].

Experiments with users in the field of HRI have the character of theatre plays, if not busking. The actions of the robots often follow scripts and occasionally the robots are even able to improvise based on their autonomous decisions. The users play the role of an involuntary actor that is called up onto the stage from the audience, similar to what is practised in busker festivals or comedy shows. While the busker (aka robot) has some understanding of the structure and goal of the act, the users are not always fully informed about what they may do or not do. They mainly try to comply with the expectations of the experimenter outlined in the description of the experiment. But even such descriptions can be intentionally misleading to achieve a certain deception. The users then have to fall back on their own experiences and ideas of robotics, which are based on the depiction of robots in the media. What we experience in laboratory experiments today is what future users will experience at home when interacting with their home robots.

The performing arts have been experimenting and testing effective methods of persuasive interaction for centuries and we agree with Guy Hoffman who argued that we can learn from their insights [7].

## 3 Short overview of robots in the media

Robots have been portrayed in the media for many years. Although general stories of artificial human beings, such as "Golem" in Jewish folklore, have been around for hundreds of years, it is Karel Capek who arguably formed the word "Robot" with his theatre play "R.U.R. - Rossum's Universal Robots" that premiered in 1921. The relationship between humans as puppets

in the theatre has also been explored by Oskar Schlemmer in his "Triadisches Ballett" [8]. There are some archetypes in that storytelling about robots that we would like to reflect upon.

### 3.1 Robots want to be humans

In many stories, robots are portrayed as wanting to be human, despite their superiority in many aspects, such as strength or computational power.

This desire to become human is the central story line for Isaac Asimov's "The Bicentennial Man" in which a robot named Andrew Martin is following a lifelong plan to become a fully recognized man [9]. The book was the base on which the movie of the same name was released in 1999, featuring Robin Williams as Andrew Martin. Besides becoming physically more human-like, Andrew Martin also fights a legal battle to gain full legal status. He is even prepared to accept mortality to gain this status.

Other robots, such as the replicant Rachael in the movie "Blade Runner", based on the book by Philip K. Dick [10] are not even aware of the fact that they are robots. The same holds true for some of the human-like cylons in the 2004 TV series "Battlestar Galactica". Not being aware of the nature of your own existence is possibly the highest form of human-likeness. A prime example of a robotic character that is aware of its robotic nature is Mr. Data from the TV series "Star Trek – The Next Generation" (see figure 1) played by actor Brent Spiner.



Fig. 1. Mr. Data played by Brent Spiner.

Mr. Data is stronger, has more computational powers and does not need sleep, nutrition or oxygen. Still, his character is set up to have the desire to become more human-like. Mr. Data's main difference from humans is his lack of emotions.

Steven Spielberg's movie "A.I." based on Brian Aldiss's short story "Super Toys Last All Summer Long" [11] accepts the main premise that robots lack emotions, and hence Professor Allen Hobby, played by William Hurt, builds the robot David that does possess the ability to love.

These three archetypical examples are only the tip of the iceberg. The appeal of this storyline stems, in our opinion, from our inferiority complex. Already a hundred years ago we were building machines more powerful than us, and there has also been major progress in the area of artificial intelligence. On May 11, 1997, the "Deep Blue" computer won the first chess match against a world champion. In 2011, the computer Watson won the game quiz show "Jeopardy". Both computers were developed by the IBM Company. In light of this progress, it is easy to imagine how robots in the future might be strong and intelligent. Humans would be therefore be reduced to an inferior position. By giving robots the desire to be human-like, we rescue our self esteem. We flatter ourselves by making robots wanting to be like us.

Rational problem-solving and calculations have been the prime focus of the development of computers and hence it comes as no surprise that SciFi authors consider emotions to be a feature that all robots would lack. It would be a crucial desire of robots to feel emotions. It has been shown that humans require emotions to act intelligently but the same does not hold true for machines. Moreover, several computational systems of emotions have already been successfully implemented. The computer programs implementing the so called "OCC Model of Emotions" [12, 13] are prime examples. Equipping robots with emotions to finally make them human is therefore an archetypical story line.

But we are not only flattering ourselves. Our need for appreciation goes beyond that. We want to be creators of life and create machines that are not only in our image, but that even admire us. Professor Allen Hobby,

creator of the emotion robot, puts it like this in the first minutes of the film "A.I." "In the beginning, didn't God create Adam to love him?" We are afraid of entities that are stronger and smarter than us and hence we make them to want to be like us and love us. It feels much better that way.

### 3.2 Robots will kill all humans

Another archetypical story line is the robotic uprising. In short, humanity builds intelligent and strong robots, then the robots decide to take over the world and enslave or kill all humans. Going back to the example of Mr. Data, he has a "brother" named Lore that possesses an emotion chip. Lore follows this typical path of not wanting to be like a human but instead wanting to enslave humanity. Other popular examples are "The Terminator" (1984), the cylons on the 2004 TV series "Battlestar Galactica", the Machines in the movie "The Matrix" (1999) and the robots in the 2004 movie "iRobot". The latter is based on the book of the same name by Isaac Asimov. Asimov coined the term "Frankenstein Complex" to describe this archetypical storyline.

This archetype is built on two assumptions. Firstly, that robots resemble humans. The robots have been designed to look and think and act like their creators. However, they exceed their creators in intelligence and power. Secondly, once they interact with the now "inferior" human species, they will act exactly as humans have historically acted when they have encountered so called "inferior species". The example of the Spanish Inquisitors and the German Nazis provide horrifying examples on how one "superior" race enslaved and killed an "inferior" one. And since robots resemble humans, they would also be likely to enslave and kill humans. It can be argued that even today the developed countries take advantage of the less developed ones, but we certainly have widely overcome slavery and genocide. It still occasionally takes place, but is condemned by the international community.

It is time that we overcome this superficial view that all superior robots would have nothing better to do than to enslave and kill humans. Several science fiction authors have already proposed future scenarios in which superior robots quietly and positively influence human society. In Isaac Asimov's "Prelude to Foundation," he

describes a robotic First Minister that keeps the empire on the right track. Interestingly, the First Minister hides his robotic nature. He is a very human-like looking robot, but needs to resort to various strategies to blend in. He does, for example, eat food, despite the fact that he cannot digest it, collecting it in a pouch that can be emptied later. Here we have a scenario in which a superior being helps the human society behind the scenes.

## 4 Framework for performing robots

The goal of our framework is to provide a high level categorisation of human-robot interaction. First we will discuss the actual implementations of performing robots before reflecting on different types of interaction themes.

### 4.1 System Architecture

On a high level of abstraction, theatrical robots can be categorised by two factors. The Locus of Control factor describes where the control unit for the robot is located, and can either be inside the robot or outside of it. The Control Entity factor can either be human or the robot itself.

	Locus Of Control	
Control Entity	Inside	Outside
Human	Guy in a suit	Puppeteering
Robot	Autonomous	Robotdrone

Table 1. System Architecture

With this matrix in place (see table 1) we can now illustrate the four quadrants with some examples. The "Guy in a Suit" quadrant is populated with robots that are operated by a human placed inside the robot. Possibly the most well known example might be The Tin Man from the movie "The Wizard of Oz" played by Jack Haley (see figure 2 or 3CPO from the movie "Star Wars".

One of the difficulties of this approach is that the robot needs to have roughly the shape and size of a human. George Lucas cast Kenny Baker, who is 112 cm tall, to operate the R2-D2 robot in the movie Star Wars. This allowed him to give R2-D2 a distinctly different shape. Lucas possibly got this idea from Douglas Trumbull's 1972 film "Silent Running", where double-amputee Mark Persons acts inside Drone 1 (Dewey) (see figure 3).



Fig. 2. Jack Haley as the Tin Man in The Wizard of Oz



Fig. 3. Mark Persons inside of the robot Dewey.

For movies, it is no longer necessary to use the Guy in a Suit method, since modern Computer Generated Graphics (CGI) can easily create realistically moving robots. But for a theatre play, this approach is still the most common method since it barely requires any technology. All the motions and behaviors are directly controlled and performed by the actor. The illusion of a robot can even be created by movements alone. In the popular robot dance style, dancers create the illusion of being a robot by very abruptly stopping movements (dimestop) and by constraining the degree of freedom of their body. Both methods imitate typical movements of robots that have electrical motors.

While humans try to dance like robots, robots, ironically, try to improve their dancing skills to become more human-like. Of the more well-known examples of

robotic dance-like practices there were the participants of the Daft Punk Aibo Dance Competition in 2005 organised by Sony, and the many dances of the Nao robot, such as in Michael Jackson's famous "Thriller" dance. While there are many examples of dancing robots, there are very few that are built to dance together with humans. The best such dancing robot is the Partner Ballroom Dance Robot (PBDR) that allows humans to dance in the classical ballroom style with the robot [14].

## 5 Theme types

Now that we have a first overview of robots in the media, we may now proceed to define our research question: **What is the role of robots in theatre and in what direction can we take it in the future?** From a conceptual point of view, robot theatre plays are typically of four types. They can either focus on the similarities or the differences between humans and robots, and in terms of either their body or their mind (see table 2). Dixon supports this view by stating that artists explore the deep-seated fears and fascinations associated with machine embodiment in relation to **two distinct themes: the humanisation of machines and the dehumanisation of humans** [15]. We extend his framework by dividing these two themes into the physical embodiment and the mind. We thereby define four types of themes (see table 2).

	Mind	
Body	Similar	Different
Similar	Type I	Type II
Different	Type III	Type IV

Table 2. Topics of HRI in the theatre

These four types of topics can of course be mixed. If we take the example of Mr. Data from above, he looks very much like a human which sets our expectations accordingly (Type II). It then appears dramatic and surprising if Mr. Data is able to enter the vacuum of space without taking any damage. In the movie Prometheus, the android David, played by Michael Fassbender, is wearing a space suit when walking on an alien planet. Wearing this suit does not serve a functional purpose since David does not require air at all. The following dialog emerges:

**charlie holloway:** David, why are you wearing a suit, man?

**david:** I beg your pardon?

**charlie holloway:** You don't breathe, remember? So, why wear the suit? **david:** I was designed like this, because you people are more comfortable interacting with your own kind. If I didn't wear the suit, it would defeat the purpose.

Again, the apparently human embodiment sets our expectations and when a difference to humans is displayed, it surprises the audience. Godfried-Willem Raes with his robot orchestra takes a different approach. He emphasises the equality of robots and humans in his theatrical performances (Type I).

He argues that:

*If these robots conceal nothing, it is fairly self-evident that when their functioning is made dependent on human input and interaction, this human input is also provided naked. The naked human in confrontation with the naked machine reveals the simple fact that humans, too, are actually machines, albeit fundamentally more refined and efficient machines than our musical robots. [16]*

An example of Type III could be Johnny Five from the 1986 movie "Short Circuit". Although Johnny Five has a distinctly robotic body he expresses human emotions, which suggests that his mind is similar to humans.

This contrast between robots being similar or different to humans is certainly one of the most often-used story elements of robots in the theatre and movies. But this view on human robot relationships is superficial. It is like admiring the eye shape or coloring of someone from a culture that you have never encountered before. At the beginning, this might be fascinating, but soon enough we understand that there is much more to this person than his eyes or color. The four types of robot theatre plays described above can also be applied to human-human relations.

## 6 Conclusions

The story archetypes and theme types proposed appear frequently in the media. They address our inner fears and fascinations when interacting with robots. Are we like robots? Are robots like us? And if so, will

superior robots act as badly as humans have done when encountering inferior beings? We may ask ourselves why these questions are so persistent in the media. The most obvious answer is that stories need to have a conflict to generate tension. A fictional world in which everybody is happily living together is unlikely to capture the attention of the audience. Pitching evil robots against good humans does not only serve the purpose of creating a conflict, but also triggers an "in-group" effect. We humans feel that we need to defend our species against the "out-group" robots. This division can then be challenged by introducing robots that are indistinguishable from humans, such as in "Battlestar Galactica". This creates a great uncertainty and this creates tension. We wonder, is the character a robot or a human? And if so, is he good or evil?

The matching of evil robots and good humans is most persistent in Western culture. Robots are extremely popular in the Japanese media but here we can observe a more nuanced balance. Robots such as "Atomic Boy" are good characters that help the humans against other evil humans. These diverse scenarios break the "Terminator Pattern" and allow us to consider the relationship between humans and robots in more depth. The research on HRI cannot shy away from the representation of robots in the media and the elicitation of the associated fears since this is what the current users are aware of. It might be useful for HRI experiments to take away some of the ambiguity when confronting users with real robots. It should be clear that the robot is a machine, and what its abilities and intentions are.

But we do not only need to take past exposures to robots into account, we also need to present our users with positive and realistic visions of the future. Notable exceptions from the gloomy visions in the media are in the TV series "Futurama" by Matt Groening and the Movie "Robot and Frank" by Jake Schreier. In both shows, a vision of the future in which humans and robots live peacefully side by side is depicted. Moreover, they even become friends. Thinking about how we develop our relationships with robots is one of the most important problems in HRI.

But there is also a positive vision for the performing arts in human-robot interaction. Home theatre systems can now become what their name promises. Imagine a

future in which you do not download the movie, but in which you download the theatre script into your robots. You can then either watch the robots perform the play or even join in. It is important to notice that robotics has in the past and still is today being used to automate tasks that we do not want to perform ourselves. Industrial robots, for example, were introduced to relieve us of difficult and repetitive manual labor. There is little use in automating tasks that we actually enjoy doing. This does not mean that there is no place for robots in the theatre at all. Plays that actually deal with robots should of course be cast with robots.

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# Beyond Screens. Exploring product dynamic features as communication means

## **Abstract**

Product semantics has been studying how product sensory features convey implicit messages to users for decades. However, thanks to technology advances, traditional static product features (such as its shape, texture, colour, smell) are becoming dynamic, able to change actively over time. These new properties might be employed to communicate dynamic information to users. Exploring how this sensory communication can be performed, and the advantages and limits connected to dynamic products, is the aim of this paper. To achieve the goal, three studies have been conducted: a case studies analysis, a design workshop and interviews with users. Results show that dynamic products can communicate messages to users and can also enhance the user experience, by making the communication both more effective and engaging. However, some difficulties have been highlighted, mainly related to the designer's ability to control those dynamic features. The work gives an overview of the new category of dynamic products, together with their advantages and limits, when design theory still lacks the knowledge to support practice; it thus constitutes a starting point in the exploration of an emerging scenario for the communication from products to users.

## **Keywords**

Dynamic products, communication, senses, user experience, product design

## **1 Introduction**

Artefacts have the ability to communicate to users by means of different channels. One is that of the product sensory features (like its shape, texture or colour), which convey messages to users through an implicit language - the "product language" [1, 2]. The meanings transferred by this channel are intrinsic to the product, casted in its matter by designers to remain (almost completely) static during the product life, even if apt to different interpretations. For instance, the shape, material or motor sound of a sport car might be associated to the idea of speed, luxury and social power, and designers have to control such product features in order to convey the intended messages to users.

The other media is that of information displays, in the form of digital screens, which transmit messages mainly connected to phenomena that are extrinsic to the physical product [3].

These two layers of information have remained separated for some time, since screens and displays were being added to the physical substrates of products as external and independent elements. Until something has changed. The digital and physical world have been gradually merged in a unique and complex layer of "bits" and matter [4], making it always more difficult to distinct the virtual from the real. Such a process opens new scenarios for product design, since the massive

invasion of technology into objects affects not only the functions and performances of products, but also their aesthetics, sensory properties and meanings, bringing forth new interaction modalities and new media for communicating to users.

The following paragraphs will briefly present the main characteristics of the sensory and digital communication performed by products, to finally introduce a peculiar novel kind of communication, which is the focus of the present work.

### 1.1 Sensory communication

Sensory product features (e.g. shape, texture, sound, temperature, smell, etc.) convey messages to users, who perceive, interpret and associate meanings to them. The communication performed by product sensory features can be divided into two layers. The first layer of communication is static and related to the product itself. Through the product language [2], this layer conveys to users intrinsic messages, which are related to what product semantics has defined as: description, expression, exhortation and identification [5]. Different scholars have proved that the aesthetic features of artefacts (shape, colour, material, etc.) have semantic functions themselves, since they affect the interpretation of the product, such as its character or personality, affordances, or gender associations [2] [6]. As Crilly states, semantic interpretations and symbolic associations are triggered by the physical qualities of artefacts, which are often understood as the visual qualities of products, but can also be related to other sensory features, like the tactile or auditory ones [5].

The second layer concerns the natural changes these sensory features can undergo. For instance, a change in the temperature of the cup one is holding may tell that the tea just poured in is very hot, or a change in the shape of a carpet may tell us that someone has trampled it. In this case, we (consciously or not) interpret products as detectors and indicators of changes of the environment. These changes can also result from something occurred inside the product. For instance, the sound of a washing machine motor reveals it is working, the temperature of a computer tells us if it is on or off, and so on. In all these cases, we receive information about situations that are external (or internal) to the products, which naturally modify the

physical and sensory features of the objects. Thus, we are accustomed to receive and elaborate these dynamic messages while interacting with products. However, while the first layer of communication (the product static appearance) is designed and controlled by the designer, the second one follows instead natural and physical laws. They differ one from another because of the content of the communication (intrinsic and “fixed” in the first case, extrinsic and dynamic in the second one) and the possibility to control them.

### 1.2 Digital communication

Another form of communication from products to users is the digital communication. We intend by digital communication the transmission of messages coming from the world of digital information, which relies mostly on interfaces.

Environments, spaces, products and people are more and more connected or integrated with sensors, technology and smart systems, which are able to produce a lot of data that have to be communicated to users. Products are becoming mediators between the information such intelligent systems want to convey and the user. The easiest way to do that is to add digital interfaces to products, in the form of screens. As Krippendorff and Butter state, products can convey messages related to external situation through the media of information displays (interfaces). These messages have a dynamic nature, since they refer to changing situations and events, and adopt an alphanumeric, iconic and graphic language [3].

Nevertheless, digital screens are not the only way for users to have access to the digital world. During the last decades, disciplines such as interaction design and HCI have been trying to reconnect the digital to the physical world. Under the umbrella name of “tangible interactions”, many approaches have been developed in order to find new ways to bridge tangible products and virtual bits, starting from the assumption that traditional digital interfaces need to be redesigned [7]. Indeed, their main limit lies in the constraints of the two-dimensional screens, which lack the complexity of the sensory and physical experience we have while interacting with the real world [8]. Some examples of these directions are the works of Ishii and Ullmer (tangible media) [9] and Van Campenhout et al. (tangible interactions)

[10]. Other approaches to the question can be found in ubiquitous computing and calm technology [11, 12], and ambient interfaces [13]. Some authors also explored the aesthetics of technology [14], the sense of presence and expression in technological artefacts [15], and new ways to address form and materiality in interaction design [16].

However, none of them specifically analyses how products can communicate dynamic messages to users without relying on traditional interfaces. We believe product design can fruitfully face this issue, as technology is always more affecting the design of artefacts by opening new scenarios for the manipulation of product physical features.

### 1.3 Hybrid communication

One of the scenarios technology is opening concerns the transformation of the product appearance. The traditional static appearance of objects (intended as the ensemble of visual, tactile, auditory and olfactory features), can now become dynamic, for it can be automatically transformed (in an active and independent manner) by electronic controllers, devices and smart materials. The colour, the shape, the tactile properties (like texture and temperature) of products, the sound emitted or the smell released by artefacts, can change over time during the product life, in a reversible manner.

That creates a new means of communication, since, as we previously argued, a change in the sensory features of products can tell something about internal or external situations. Although this change is usually natural, because determined by transformations in the physical environment, what is new is that now it can be provoked and controlled by intelligent components in the product. Products showing dynamic appearances (from now on, dynamic products) can thus convey messages similar to those transmitted by interfaces, but through a different media: changes in the sensory features. For instance, weather conditions may be conveyed by a digital screen, with numbers and verbal language, but they can also be communicated by a light changing in colour according to the temperature (Fig. 1).

The possibility to communicate through dynamic products is the topic this work wants to investigate. Design researchers have developed many examples of these products in the form of research prototypes, but

theoretical literature on this issue is very scarce, and we could not find specific studies aimed at generating theoretical knowledge around this topic. That results in leaving a gap in the (product) design literature and in the designers' education. For the reasons explained so far, we believe this field can be full of possibilities, in particular from the user experience point of view, and thus worth exploring.



Fig. 1. Ambient Orb by Ambient devices. The colour of this lamp changes to inform about the weather conditions. The change in colour can also show other kinds of digital data, according to user's preferences.

## 2 Aims

The present work aims to explore if dynamic products (intended as products that show an active and reversible change in their sensory features) can be a valid alternative to interfaces in the communication of messages from products to users. In particular, the paper focuses on the analysis of the limits and potentials connected to the use of dynamic products, both from the designers' and the users' points of view.

In order to find out if and why it would be convenient to adopt dynamic products for the communication of messages to users, an analysis of the state of the art has been performed as first step. Then, a test with a group of designers has been set up, and finally qualitative interviews with users have been performed. As a result of these investigations, we extracted a number of insights related to the advantages and disadvantages that can be encountered both in the design and in the use of dynamic products, which constitute the results and the main findings of this work.

### 3 Methodology

The investigation of the field of dynamic products has been performed by the authors through three different studies, each one adopting diverse perspectives and methods, but all aimed at exploring, from a particular point of view, different aspects of the analysed field. The present work introduces and critically discusses the three research experimentations, in order to create an overview able to describe the potentials and limits of dynamic products by different perspectives. The next paragraphs present such studies, by synthetically explaining their approaches, their processes, and the results useful to fulfil the purpose of this work. The research methods and procedures of the Studies 1 and 2 are presented to a very concise extent, since exhaustive details can be found in related works published by the authors.

#### 3.1 Study 1. A framework for dynamic products

The first study followed a theoretical approach and aimed to shed some light on the issue of dynamic products, by creating a general descriptive framework for this category of artefacts. In particular, its goal was to analyse the role of different sensory modalities in the communication of messages.

It consisted in a case studies analysis, performed through the collection, selection and examination of 48 samples of dynamic products (chosen among concepts, prototypes and commercial products on the basis of their novelty factor. Indeed, we discarded products that adopt standardized dynamic signals, such as common warning lights or sound alarms embedded in appliances). This process was part of a previous study conducted by the authors, in which a descriptive framework for dynamic products has been proposed as result [17]. The framework bases on the identification of three criteria useful for the description and categorization of dynamic products: the source of the message, the aim of the message, and the receiver of the message (i.e. the stimulated sensory modality).

**The message source.** From the samples collection and analysis, it emerged that dynamic products can convey messages coming from three main sources:

- **The product itself.** Dynamic products can tell something about their internal physical state (like temperature), their functions, the action they are performing, their energy consumptions, and so on. (Fig. 2)

- **The environment.** Dynamic products can give information about states of the environment (e.g. the temperature of a room, the level of pollution in the air, the energy consumption), which they are indicators of. (Fig. 3)
- **A person.** Dynamic products can be used in order to convey messages coming from a person. For instance, they can be employed to communicate the inner states of the person (like emotions) but more often they are employed in distance communication, to replace the communication based on verbal language. (Fig. 4)



Fig. 2. One Kettle by Vessel Design. The kettle changes its own surface when the water boils



Fig. 3. Flower lamp by Interactive Institute Swedish ICT. The lamp opens and closes to communicate the electricity consumption of the household.

**The message aim.** The second criterion used to analyse and describe dynamic products is the message they convey. Since the messages transmitted by the samples vary a lot, it was not relevant to categorize them according to the content of the communication.

The parameter we identified to describe the message concerns the aim of the communication. Indeed, dynamic products can convey messages directed to:

- **Sharing some data or knowledge to the user** (for instance the emotion a person is feeling, Fig. 5, or the temperature of a room). In this case we defined this message **cognitive**, or **data-aimed**



Fig. 4. HugShirt by CuteCircuite. This shirt makes people send hugs over distance, by reproducing the sensation of a hug on the body that is wearing it.



Fig. 6. I-Dratation by Cambridge Consultants. The bottle tells the user when s/he needs to drink water, by emitting a flashing blue light

- **Exhorting the user to take a short-term action** (for instance, encouraging the user to drink water, when s/he is dehydrated, Fig. 6). In this case we defined the message **exhortative**, or **action-aimed**

**The message receiver.** The third criterion we considered is the message receiver, that is the user's senses. The four main sensory modalities at stake in the interaction with objects are sight, touch, sound and smell. Dynamic products convey messages by means of transformations in their appearance, which activate one (or more) of these modalities. For instance, changes in colour, shape, or light stimulate sight, while changes in temperature or vibration activates touch. The possible product transformations, grouped by the modality they activate, were summarized and represented by a sensory map (Fig. 7).

**The roles of senses.** The identification of the three criteria let us better understand in which situations dynamic products can be employed to communicate to users and what kinds of messages they can convey. Moreover, we deepened the analysis by investigating which senses dynamic products address and what transformations of the product appearance may be designed, and we summarized them in the sensory map.



Fig. 5. Bubelle by Philips Design. The dress recognizes the person's emotions and reproduces them through different colours of the lights



Fig. 7. The sensory map collects the possible transformations of products sensory features. The changing stimuli are grouped according to the sensory modality they activate.

Starting from the classification made so far, we also tried to understand if different senses played a particular role in specific situations. In other words, we checked if certain senses or stimuli were adopted with more frequency to convey messages coming from a specific source, or with a specific aim. Since this was the case, we tried to analyse the reasons why it happens [18].

The results we obtained show that all the senses can be addressed by dynamic products, and that each sense may have specific roles in the communication of different messages. Indeed, they seem to have particular features and meanings, which make them better suit specific situations. As an example, in our product sample, touch is often adopted to communicate messages coming from a person, while it is rarely chosen in the communication of messages coming from environment or product. Moreover, specific tactile stimuli are adopted to convey messages coming from

person, like temperature and pressure changes. A different tactile stimulus, vibration, is only adopted to convey messages coming from the environment, and always, in the collected samples, with an exhortative aim (to induce the user to rapidly react). Thus, touch seems to be suitable to convey the idea of intimacy, in human-human interaction, but also to alert the user by vibration. In addition, visual changes came out to be the most used stimuli in every source category, thus confirming the dominance of this modality both in the human perception, and, especially, in the designers' attitudes [19]. To conclude, selecting a sense instead of another is never a neutral choice. On the contrary, such a choice may affect the kind of interaction and the experience generated, as we will better explain in the discussion paragraph.

**Results.** This study confirmed that dynamic sensory features of products can be adopted to communicate messages to users to a new extent, which constitute an alternative to traditional interfaces. It demonstrated that all sensory modalities can be employed in order to convey bits of information – even the most overcome by designers, such as smell.

Finally, it supported the comprehension of the category of dynamic products, by creating a descriptive framework for it, and by highlighting the different roles of senses in the communication of messages coming from specific sources and with specific aims (for more details about the research process and results, see [17-18]).

### 3.2 Study 2. Designer's perspective

The second study about dynamic products was aimed both at investigating the difficulties designers can encounter in the design of such products, and at testing how the design process of such artefacts can be supported and improved [20].

It consisted of a design workshop performed with 14 design students in the end of their master education in Design&Engineering at Politecnico di Milano, in collaboration with a worldwide company producing home appliances. The aim of the workshop was to create more pleasant experiences for users during the interaction with a domestic appliance, in particular a dishwasher. The workshop had the duration of one week, during which designers had to develop one or more innovative concepts for a dishwasher, aimed at involving the user on the sensorial level. They could focus on the redesign of both the dynamic communicative elements and the static sensory features, in order to delight users' senses. They were free to design for any sensory modality, with no constraints but maintaining the product archetype (the external shape and the main functions of the dishwasher).

The workshop was useful for us to understand the attitudes of designers, their propensity for the design of static rather than dynamic product features, and the difficulties they encountered in designing the latter.

We provided the designers with the sensory map (see Fig. 7), to be used as a supporting tool in the generation of new product dynamic features. We also performed a one-hour presentation about dynamic products, to explain how changes in sensory features could be used to communicate to users.

**Process.** The 14 designers had been working in pairs for one week, led by the authors' research group and by the company's design and marketing team. At the end of the design process, the designers produced 12

concepts, which showed both static and dynamic stimuli. The authors analysed the concepts in order to evaluate if designers preferred to focus on static rather than dynamic stimuli, and to see which senses the concepts containing dynamic stimuli addressed.

After the workshop, the designers were asked to complete a questionnaire aimed at investigating the difficulties they encountered in the design of dynamic products and at collecting their opinions about the usefulness of the sensory map and the lecture on dynamic products.

**Workshop results.** Many innovative solutions emerged on the side of both static and dynamic stimuli. Dynamic stimuli were mostly used to communicate the progression of the washing cycle: the designers tried to replace the visual screens with more appealing elements, by using lights or colours to indicate the cycle steps. For instance in "Light" concept, the designers placed a LED strip in the top front part of the appliance that changes its colour to indicate the progress of the washing cycle (Fig. 8).



Fig. 8. "Light" by M. Broggio and M. Spotti. The colour of the light changes according to the current phase of the washing cycle.

Even if the concept of dynamic stimuli is not well established in product design, half of the concepts (6 out of 12) included dynamic sensory elements. However, designers preferred to focus on the static features of products, mostly visual and tactile.

The analysis of the resulting concepts showed some critical issues related to the design of dynamic sensory features. Even though students were free to choose the sense to address in order to create new engaging interactions, most of them focused on the design of visual dynamic stimuli. They mainly comprised changes in light (both in light intensity and in light colour).

Beyond sight, tactile stimuli were investigated in two concepts, with temperature and shape transformations. Finally, one concept explored smell, by designing a dishwasher which communicates the end of its activity by releasing a particular fragrance in the environment.

**Questionnaire results.** Feedback from the designers was collected through an online questionnaire, made of both open and close questions, in order to assess the usefulness of the theoretical and practical tools.

The first part of the questionnaire investigated the designers' prior knowledge on the topic of static and dynamic sensory stimuli. Most of them had never heard about this distinction and had never been taught to consider it while designing. That reveals a lack in education about this issue, which also explains why designers were more inclined to design for the static aspects of product sensory appearance. Nevertheless, none of them declared they found it difficult to apply the notions of dynamic stimuli in their design concepts. In the second part of the questionnaire, designers were asked to give their opinion about the provided knowledge and the sensory map. Answers showed a general positive evaluation about the sensory map: it was considered a valuable basis to design dynamic products with enhanced sensory experiences. However, some designers argued that the map was too detailed and therefore confusing because it offered too many possibilities.

The designers affirmed that they would not have considered sensorial or emotional aspects in designing the household appliance if they had not been pushed by the lecture given by authors, nor would they have taken into account to design dynamic features to communicate with senses different from view.

They evaluated the lecture and the sensory map very useful to guide their design activity towards unconventional and more emotional interactions with products.

**Authors' insights.** An important element to stress is that designers were constrained by their lack of knowledge about the available technologies that can support the design of dynamic features. Feasibility was one of their concerns, and they found it difficult to design those dynamic features they were not able

to fully develop. For this reason, they mainly used light transformations. In our view, light was employed in many concepts because of its dynamic behaviour, which easily convey information and feedback about the product status and ongoing work. Nevertheless, they avoided sound (another available technology, easy to implement), because they considered it too little innovative to convey messages coming from products, and unpleasant in many cases. Moreover, they had no knowledge about sound design.

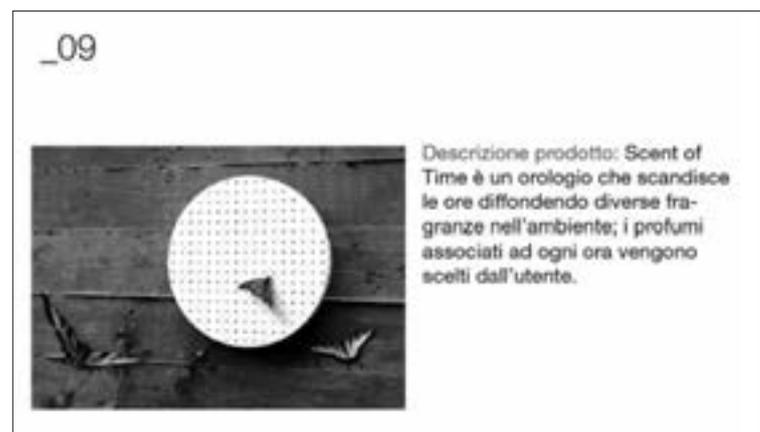
In synthesis, properties connected to the physical and tangible aspects of products, that is visual and tactile features, were the most adopted. It is important to stress that the participants were students with little industry experience, and more experienced designers might have produced more heterogeneous solutions; however, it was the scope of the study to analyse the designers' skills and knowledge provided by design education programmes.

### 3.3 Study 3. User's perspective

The last study was aimed at exploring the user's reaction to dynamic products. Indeed, in analysing the potentials and limits related to the adoption of this new kind of communication, it is necessary to consider the effects it has on the final users.

We decided to investigate the users' reactions to dynamic products by testing the product samples we selected for Study 1. Since most of the samples were not commercial products, but concepts or prototypes,

Fig. 9. Example of a card used in the interview. It shows a picture of the product, together with its description. The concept shown in the card is "Scent of time" by Hyun Choi.



it was not practicable to perform a test on the real objects. We decided to set up semi-structured qualitative interviews supported by pictures and brief explanations for every product [21]. The bits of information related to each product were summarized into a card (Fig. 9).

It is necessary to underline that a test performed just through visual images instead of real products, especially while investigating the sensory experience, presents many limits. Nevertheless, this is just a first step in the exploration of users' reactions to dynamic products, whose aim is not to evaluate the single products, but to extract suggestions, insights and general impressions about this kind of artefacts.

The aim of the interviews was to assess both the perceived communication effectiveness and the quality of the experiences elicited by dynamic products.

**Process.** As many products adopted similar stimuli to convey the same kind of message, we decided to reduce the sample of products to test. Indeed, the reduction of the sample size did not compromise the reliability of the study, since the interviews did not have a quantitative, but a qualitative approach. In order to have a good overview of the users' reactions to these products, we considered necessary to select the products to test maintaining the highest variety among the samples, on the basis of the three criteria identified in Study 1. For this reason, we selected for each source category (product, environment and person) both products conveying exhortative and cognitive messages. Within each subcategory (e.g. products conveying exhortative messages coming from environment) we picked only one product for each different sensory stimulus adopted. At the end of the process, 15 dynamic products were selected for the interviews (Fig. 2 to 6 and Fig. 10 were all part of the sample).

Five users were involved in the interviews, both males and females from an age of 19 to 60. Each user was asked to analyse three products.

The interview structure consisted of two sections. The first one investigated the communicative aspects of dynamic products (efficiency of the communication, comprehensibility and intuitiveness of the message, consistency of the activated sensory modality to the

context of use, the source and the aim of the message); the second one focused on the emotional impact of the products (level of involvement, interest towards the product, elicited emotions).

Each single interview comprised three sessions on three different products. Every session lasted about 15-20 minutes. During each session, the user was shown the card of the product, and a brief explanation of how the product works was accomplished by the authors. Subsequently, the interview was performed, following the track composed of 10 questions, 5 related to the first section (focused on communication), 5 to the second one (focused on experience). The questions led to an open discussion between the interviewer and the user. The entire interviews were recorded and subsequently transcribed by the investigators. Memos were written during the interviews, to note additional details. The recordings and memo were analysed through the methods used in Grounded Theory, with the aim to highlight significant findings. We followed an approach based on Strauss and Corbin's model, already used by previous studies in the field of user experience [22]. The findings were extracted through a coding process aimed at identifying recurrent concepts which were then clustered into categories based upon similarities. This helped us highlight and connect recurring themes. Indeed, our purpose was to identify insights related to the user experience with dynamic products.

**Results.** This section presents the results of the interviews, according to the purpose of the paper, that is to stress which are, in the final users' opinions, the difficulties and the advantages (pros and cons) founded in the use of dynamic products. For this reason, not all the findings emerged by the interviews analysis are reported, but only the elements that express the positive and negative aspects of dynamic products, as far as communication effectiveness and user experience are concerned.

*Communication effectiveness.* Users reported some difficulties connected to the communication performed by dynamic products. The first one concerns the intuitiveness of the message: in many dynamic products, the link between the stimulus and the content of the message is not direct, and the message has to be explained to the user in order to be understood. For instance, the user

has to know in advance that if the pattern on the tiles of the shower disappears, too much hot water is being used (Fig. 10). On the contrary, if a writing appeared on the wall, telling: "you are using too much hot water", the content of the message would be self-explaining. When the message was not explained clearly, users interpreted the content of the communication very subjectively, and gave it different meanings. However, in some few cases, the message was self-explaining and more objective even when transmitted only by a sensation. For instance, the users perceived the message conveyed by the Hug Shirt, which reproduces the sensation of a hug to whom is wearing it (see Fig. 4), as very intuitive. Moreover, once the message had been explained, it resulted clear and effective in the most of cases, especially when related to the intensity of something (e.g. the electricity consumption, the level of pollution in the air, the temperature), where the gradient of the information can be represented by a gradual change in the stimulus (e.g. the intensity of a colour, the density of a texture), not achievable with the same effectiveness by verbal language.

The second difficulty regards the *simplification* of the message. Indeed, sensations are less detailed and precise than verbal language, and sometimes this vagueness represents a problem for the user. For instance, this element emerged in reaction to a lamp that communicates the external temperature through a change in the colour of the light (see Fig. 1). In fact, the user considered valuable the immediacy of the sensation, but he would have also appreciated the presence of numbers telling the exact temperature, to be consulted when needed, as an added function to the product. However, the lack of details, which is intrinsic to this kind of communication by sensations, was also evaluated as positive in some cases, because it requires less effort to get the message. An example is I-dration (see Fig. 6), a bottle that tells the user when s/he needs to drink water while doing fitness, by emitting a flashing blue light. The user reported it is very useful to get the message through a flashing light, since the interpretation of the sensation is effortful, differently from reading something while you are doing physical activity. The users also reported some advantages related to dynamic products. One is *immediacy*, which is still connected to simplification. In fact, according to the users, sensations stimulate the senses in a more direct way and are more rapid to interpret, compared to

verbal language of traditional interfaces. In many cases, during the interviews, they defined the messages conveyed by sensations as direct and immediate. Sensations are also more *evident*, since they can reach the user from far and one does not have to look for the information actively. For instance, sound and smell reach the user's senses also when the stimulus is distant, and they are difficult to avoid, thus being very effective in particular contexts (e.g. when the information is urgent, or when one is busy and not able to pay attention to the message spontaneously). Users have evaluated this aspect both as positive and negative, since the sensation can also distract or disturb the person, if not designed in the right way.

The *context of use* came out to be very important in the communication of messages through sensations. In fact, in some cases, the users evaluated the choice of one sensory modality as wrong, with respect to the context or scenario of use of the product. For instance, if the product has to remind the user to take a pill, a small LED light is not considered suitable to communicate the message, since the user will easily miss the stimulus if s/he does not keep on looking at the product.

The last consideration concerns the *exhortation power* of some sensations. It came out that specific stimuli have a great alarming power. In particular, users interpreted vibration, sound and flashing light as conveying urgent information, which require an immediate action. They felt the products were asking them to do something, and they were given a strong motivation towards action. In other cases, when the message wanted to be exhortative in the intention of the designer, but it was conveyed by a change in the colour of the product, the information was interpreted as the opposite of urgent and alarming, in fact it was evaluated as suggesting or inviting.

*Experience pleasantness.* With respect to the experience, the users were asked to describe their impressions towards the dynamic products in terms of elicited emotions, engagement, pleasantness of the communication and aesthetics. We will focus here on the elicited emotions, making some brief considerations about the engagement and the communication pleasantness.

To assess the users' emotional responses, the participants were shown a list of 14 words expressing



Fig. 10. Disappearing Pattern Tiles by Interactive Institute. The pattern on the tiles disappears when the user consumes too much hot water for a shower.

emotions, among which they had to select the most appropriate ones to describe their emotional reactions to the products. The list, based on Desmet's 14 emotions elicited by products [23], reported 7 positive and 7 negative emotions. Results show that users cited 31 positive emotions to describe their experience, while they reported negative emotions only 8 times (plus one case in which the user felt indifferent towards one product). The most cited positive emotions were fascination (11 times) and pleasant surprise (8 times), followed by admiration, desire, amusement, and inspiration.

Negative emotions were almost never related to the stimulus used to communicate, but resulted from the evaluation of the aesthetics of the product, or the content of the message conveyed (e.g. a user reported dissatisfaction because the product was attractive but it communicated the level of pollution in the air, and she was not interested in receiving that message). Only in one case, boredom and delusion were expressed in reaction to the use of (a pleasant tweeting) sound by a kettle, defined not new.

The users were also asked to rate their perceived level of attraction and engagement towards the products (from 1 to 5, where 1 was very low and 5 was very high). The answers showed high ratings (equal or above 3) in all the cases but two. These negative responses were, as for emotions, connected to the little interest towards the message conveyed, and to the lack of innovation in the transmission of the message (the use of sound in the kitchen appliance). Finally, the pleasantness of the stimulus employed to communicate was evaluated, again on a 5-point scale. This time, answers were more positive than for

engagement: the pleasantness of the communication was rated very high, mostly with 4 or 5 point (high and very high). Two products were evaluated as medium, and one as low.

An interesting element that was reported by the users is the concept of discretion. Dynamic products communicate by a non-explicit language, since they do not employ verbal communication. Thus, they are perceived as more discreet in the communication of messages. This is particularly valid for messages coming from persons (human-human communication), where the use of sensations is much appreciated, it being a less direct language, more suitable for subjective interpretations.

*Dynamic products vs interfaces.* The users were also asked if they would prefer to receive the same message through a verbal or numerical language. In none of the cases, the users expressed the intention to replace the communication dynamic products performed with a traditional interface. In fact, they stated that the experience with dynamic products was more engaging and pleasant and the message more immediate, evident and discrete. In more than half of the cases, they argued that they would appreciate a more complete or detailed message, by incorporating or associating an interface to the dynamic product. Nevertheless, they would never replace the direct sensation with the interface. This is a very interesting result, for it highlights that users are ready to lose some details, in favour of more immediate sensations, less precise but more surprising; in other words, in favour of the experiences the products create.

## 4 Discussion

The results of the three studies have been critically analysed, in order to highlight and summarize advantages and limits of employing dynamic sensory features in the communication of messages from products to users.

### 4.1 Advantages

The advantages of dynamic products are mostly connected to the efficiency of the communication and to the user experience. The main benefits from the designer's point of view reside in the fact that this new product category is still unexplored and thus represents an interesting area for the development of innovative projects. Moreover, the product dynamic features

represent a new material for design, which enlarge the possibilities and horizons of the designer's activity. Benefits and potentials connected to the use of dynamic products are summarized below.

**Immediacy (of the message).** The message conveyed by sensations is more simple and immediate. It means that the communication can be more direct and can better suit some situations, for instance, when the user is under physical or psychological stress or s/he does not want to pay too much attention in decoding the message. Moreover, sometimes users are overloaded by information, even when it is not necessary: some messages do not convey complex information, and can be more easily and rapidly understood by sensations, instead of difficult cognitive elaborations.

**Evidence (of the stimulus).** The user does not have to look for the information, but in many cases the signal is self-evident and reaches the user in a more straight way (with sound and smell, but also with touch if the product is wearable) and with less effort. This is valid also for what are called ambient interfaces: they are present in the environment as constant reminders, and are easily perceivable by the user. Both evidence and immediacy may be connected to the concept of calm technology [12], which Weiser and Brown describe as the ability of technological products to address the periphery of our sensory system, thus avoiding information overload.

**Exhortative power.** Some sensations came out to be very effective in alerting and alarming the users. In particular vibration, sound and flashing light were assessed by users as exhortative stimuli. The ability to gain the users' attention and to activate them can be exploited in order to convey urgent messages, or to make the communication more effective when it requires the user to act in a short time.

**Discretion.** Communicating by dynamic products requires a less explicit language than the alphanumerical ones. This element has been judged as extremely positive in specific situations, when the user wanted to be informed about something, but in a subtle and hidden way. Moreover, relying on more discreet communicative modalities was highly appreciated in the human-human communication. Indeed, changes in the light, colour, smell or temperature of an object can communicate,

in a more gentle and implicit way, emotional states, moods, or just that your partner is thinking of you.

**Fascination, surprise, engagement.** Thanks to their unusual way of communicating, dynamic products elicit positive emotional reactions in the user. The emotional response can be described in terms of fascination and pleasant surprise. Engagement is also part of the experience generated by dynamic products, thus confirming the idea that communicating by sensations can positively affect the user's experience.

**Variety.** The broad range of dynamic stimuli gives the designers the opportunity to choose the best sensory channel in every situation. Since senses have their specificities, each of them can better suit particular contexts. For instance, touch is connected to the idea of intimacy [24], sound has an alarming power and smell is strongly linked to memories and emotions [25]. Moreover, within each sensory modality, different stimuli have different meanings (e.g. vibration is used to alert, while temperature and pressure to convey the idea of affection). Choosing the more suitable stimulus can improve the communication, by making it both more effective and more pleasant.

#### 4.2 Difficulties

The difficulties and constraints connected to dynamic products are reported below. We specified in brackets if the difficulty concerns the user rather than the designer.

**Subjectivity (user).** Dynamic products rely on sensations instead of verbal language to communicate to users. This makes the message apt to the user's subjective interpretation, since it is not explicit. The message can thus result ambiguous and the content of the information can be easily misunderstood, if not explained.

**Simplification (user).** The messages conveyed by sensations result simplified, since complex data are difficult to transmit by basic sensory transformations, in an effective way. If this can be judged an advantage in some cases, it also represents a limit, since accuracy is reduced and the user can just get approximate data. Complex information came out to be better conveyed by the verbal or numeric language.

**Sight dominance (designer).** Study 2 demonstrated that designers are used to handle the visual and tactile

qualities of products, which are their tangible features. Controlling more intangible elements, such as sound and smell properties, seems to be a more difficult task: in the experiment, none of the concepts focused on sound, while smell was investigated in only one project. Moreover, the fact that vision was the most investigated sense, confirms again the dominance of this modality in the approach of designers [19].

**Educational gaps (designer).** The questionnaire in Study 2 provided some evidence that designers are not taught how to consider product dynamic features as a media to communicate to users. Knowledge on this topic is very limited, and the natural inclination of designers is to design for the static sensory features of products. Even when explicitly required to design for dynamic features, designers found it hard to explore different sensory modalities (they focused on sight, and mostly with light changes).

**Technical feasibility (designer).** Another difficult that designers can encounter in the development of dynamic products is their technical feasibility. Indeed, as Study 1 demonstrates, the dynamic products developed so far in the design practice are mostly in form of concepts and prototypes, rather than commercial products. This for two reasons: on the one side, technologies supporting the functioning of dynamic products are still little developed or far from being easily implementable in commercial products (also because of their cost). On the other side, designers often do not have enough knowledge about the technical possibilities that are being developed to support dynamic features. The most available technologies on the market for dynamic products implementation, which can be found in commercial artefacts, are thermo-chromic inks, lights and auditory signals.

**Context dependency (designer).** The design of dynamic products must take into account the context and the scenario of use. It means that it is not sufficient to identify the most suitable sensory modality to activate, and the most appropriate stimulus, consistent to the message to convey. The scenario in which the interaction will take place plays a fundamental role in the design of the sensory communication, since senses have objective constraints, which must be carefully considered. As an example, sight should not

be addressed if the object is designed to be hold in a pocket. It may seem a banal consideration, but not few products, among the collected samples, showed a lack of attention on this aspect.

### 4.3 Limits of the study

The findings we propose in the discussion cannot be considered exhaustive, as they present limitations connected to the research process methodology. As far as the designer's perspective is concerned, it is important to remind that the results are based on an experiment with graduated design students, with little industrial experience. Their educational background, which results from the industrial design programme in one specific university, may be different from the one of designers coming from different contexts. However, our interest was to investigate how product designers having no specific education in user experience or interaction design would address the design of dynamic products. With respect to the user's perspective, methodological limits lie mainly in the fact that not real, but hypothetical designs were tested. Users were asked to discuss dynamic products by observing their images and descriptions, instead of by interacting with them. This represents the main limit of the study, also because the quality of the sensory experience cannot be investigated through such a process. Although this approach is not sufficient to explore all the aspects of the experience elicited by dynamic products, still it gave interesting insights about the level of acceptance of these products, the perceived effectiveness and emotional values.

## 5 Conclusions

This work presents and analyses three studies aimed at investigating, from different points of view, the possibility to communicate by dynamic products. The studies adopted different perspectives, in order to identify advantages and difficulties in both the design and the perception of this kind of products. Results emerged by this first analysis show that the advantages are mostly connected to the user experience, which can be enhanced and enriched by the communication performed by dynamic sensory features of products. On the contrary, difficulties can be found mainly on the designer's side: his education, knowledge and inclinations do not support an exhaustive exploration of different sensory channels. Moreover, technical

feasibility and the scarce availability of solutions on the market, seem to reinforce the constraints of designers. The picture this investigation returns aims to give an initial reading of the current situation in the development, diffusion and users' acceptance level of dynamic products. Again, the intention of this analysis is not to be exhaustive, but to constitute a first attempt to shed some light on this emerging area of design. Further studies are necessary to better comprehend the limits, potentials and implications connected to dynamic products. However, the goal of this work is also to encourage the design community to open a debate on such themes, as the practice of design is developing solutions in this direction, while theory still lacks the corpus of knowledge able to support the designer's work.

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# Hive-Design for Big Data

## **Abstract**

An epistemologic framework, this paper draws from social sciences, media theory, philosophy, business, and the practice of design to develop a comprehensive knowledge construct deciphering the role of the designer in an age of Big Data. From this framework, areas of design research and practice are defined. Practice methods for the designer as an executive member of the business strategy team are framed in terms of efficiency and value. The possibilities for implementing crowd-sourced subjective and multi/media data, interpreted by the vast numbers of social media users at a scale even greater than big data, are explored - hivedesign for big data. It is argued that designers are best qualified to perceive, interpret and contextualize phenomena such as mass customization, the quantified-self and wearable interfaces in an effort to achieve an optimized and rich whole data synthesis.

The paper asserts:

- **Big Data is quantifiable but ultimately without much meaning.**
- **Soft Data, four times as big as Big Data, requires human minds to interpret.**
- **Data without Design is insufficient to make rich decisions**
- **Whole Data Research integrates structured and non/structured data and is the ideal information construct to generate the most valuable knowledge**
- **Social Media Ontology describes identity and**

existence as mediated through the agency of social media interfaces, presence and status

- **Interfacing and the Data-fied Self is the phenomena of self-monitoring and engaging in biological/technical interfacing through wearable technology**
- **Mass Customization and Device Topology describes creating value and longevity for the platform and tools by empowering individuals to personalize the performance of his/her device.**

## **Keywords**

Design optimization, design strategy, device topology, hivedesign, whole data

## **Introduction: Design is Optimization**

Those fortunate enough to collaborate across disciplines may have heard well-meaning team members ask, "What exactly is design?" A colleague from Engineering, somewhat self-consciously, admitted he thought it was the designer's job to tell him if our (his) final product should be "square... or round". He was genuinely struggling to understand what design could offer early-on in project development. "What exactly can a designer contribute?" I told him, "Design is optimization; designers interpret vast amounts of data on materials, production methods, technology, economic conditions, cultural, ethical, historical and environmental issues, aesthetics, performative systems,

and ergonomics. Designers contextualize that information and assimilate it to create an optimized result." After being initially confounded, he then knew what to expect and became an enthusiastic and demanding partner.

With the explosion of data now available due to the social media revolution, intuitively, many people are asking a similar question. Can a designer contribute to the Big Data mélange other than just designing content? As more and more data becomes available, it is becoming difficult to communicate larger amounts of more nuanced data in a way that can be effectively absorbed by the receiver. Words and text alone are no longer up to the task. People are supplementing abbreviated word exchanges with images, video, music, emoticons, and memes to quickly convey a richer meaning. Therefore, in this era of Social Media we've moved from word to image in order to facilitate greater efficiencies in swarm communication.

Even hard data has become affected by expectations of more affective information. It is no longer sufficient to present hard data through traditional means; those who aspire to communicate their findings are expected to do so through infographics. As design researchers work to quantify and qualify the multifarious meanings in the data swarm; many models of thought developed by linguists and behaviorists prove to be useful structuring tools (Sausaure, Baskin, Meisel, Saussy 2011). Interpersonal and public communication has come from being primarily gestural and audible to super-gestural and super-audible. In our interconnected world, imparting meaning demands creating engaging content and further stimulating the higher perceptual senses. Like sensing an approaching storm, we are aware of the energy of social media, just beneath reliable perception - much in the way some animals sense acoustic pressures beneath the frequency of audible sound. Analogous to infrasound, this energy can cover long distances and is not susceptible to interference. We can sense energy without knowing what it is. Perhaps this is an indication that our bodies are adapting to the overwhelming flow of data.

### **Why HiveDesign?**

#### **Social Mediators = Mass Customizers**

Enormous energies have been invested in an effort to quantify the Big Data produced by our current

state of technological information generation. There are ongoing heroic efforts to find ways to fabricate intelligence from data. Those efforts have been concentrating on easily quantified hard (or structured) data. The real challenge has been to garner intelligence from the soft (or unstructured) data. That data includes not only the subjective data of text messages, images, reviews, rankings, videos, music, and memes but also the ways in which this data is shared (IBM 2013). There is an epistemic culture to our social media information exchanges. Per Knorr-Cetina, an "amalgam of arrangements and mechanisms - bonded through affinity, necessity and historical coincidence - which in a given field, make up how we know what we know" (Knorr-Cetina 1999). Evaluating the information artifacts containing situational, cultural, symbolic and aesthetic content is key to discovering meaning in our mediated information exchanges. Designers have a unique skill set enabling them to interpret and translate data relative to the social media epistemic culture.

Envisioning social media networks as hives provides the analogous framework to address the component constituents, ubiquitous communication, fluidity and unity of purpose (Burns, Stalker 1961). Every individual engaged in social media has made choices as to the ways in which they want to represent themselves. Those choices are design choices. Every person with a profile page is aware of the personal affect they wish to convey. The community encourages individualization and sharing. The agency provided through a personalized interface transforms social mediators into mass customizers. A shared proprioceptive sense of the social media system provides an awareness of the spatial relationship amongst the various components and the sense of balance achieved when all parts are functioning correctly. The mass customizers serve to expand the power of the social media hive by collecting, creating and distributing content that is not only personal but also political, commercial and entertaining. We have reached a point where all actions in society must deal with the social media hive. Everyone is a hivedesigner with a keen awareness of the cultural and contextual implications their actions may have.

#### ***The HiveDesign Manifesto:***

We are searching for a new intelligence from the Big Data of 'the internet of everything'.<sup>1</sup> We are witness to

<sup>1</sup> Refers to the Cisco campaign by Goodby, Silverstein & Partners

the revolutionary impact of the Big Data/New Media Synthesis. We hope to discern a data of desire from the posts, tweets, pins, reviews, etc. We customize, create and share our data experience. We define our identity through our choice of device and tools (apps). We hive as a result of our desire for interaction and knowledge. We quantify ourselves through wearables and visualize that data to improve self-diagnostics, challenge and motivate ourselves. We interface everywhere. We create and recreate our identity. Our agent is social media and that agency provides a space of reflection and exchange. We engage in processes of assimilation, interpretation, and creation in all we share. Our presence can be felt everywhere. We initiate experiences, invite input, create desire, generate meaning and knowledge to affect our shared spaces of commerce, communication, entertainment and politics. We want you to like us, so we try hard to be likeable. We want you to look at us, so we try hard to be good-looking. HiveDesign is emergent, collective and agile. HiveDesign is always on, does not sleep, possesses the adaptability and intelligence of a swarm and is in constant motion. HiveDesign collectively possesses a higher consciousness. HiveDesigners are distinct, egocentric, sentient individuals working collectively in hypertime and heterospace by virtue of our shared devices, spaces & tools, if not a shared agenda. The behavior and particularities of the hive cannot be predicted by the behavior and particularities of the individual hivers. It is impossible to observe the hive without engaging it. The hive is inevitable and you are likely part of it. Welcome.

### **20% is not Big Data**

Big Data is about going wide and thinking fast. It holds quantity over quality and has achieved superior results in doing so. It is logical: processors analyzing data; similar systems correlating and resolving meta-data just as fast as the advances in technology will let them. This works well for data that can be tagged or put into a database or other structure. Information that can be described numerically or has limited variables of associations (like language) are the Big Data hotspots at the moment. Big Data through Analytics becomes **Meta Data: the data about data, highly abstract and impersonal and beyond the scale of the individual.**

*"...90% of the data in the world today has been created in the last two years alone. This data comes from everywhere: sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals to name a few. This data is big data" (IBM 2013).*

The real windfall comes as the tools of analytics to interpret that big data fall into place. The predictive power, potential for more efficient allocation of resources and access to previously unrevealed markets is stunning. Google is the most visible player in the analytics game with advanced translators and attempts at predicting epidemics before official institutions are able to do the same (Google 2013). They quickly generate the structured data for analysis. A Health Department must consolidate reports after illness has been tested for, confirmed and reported. This type of data processing is done by humans. It is good, quality data and it is inherently deep and slow. **Consequence:** fewer lives saved due to identifying the outbreak so late. This Big Data Analytics revolution is a game-changer on a societal scale. A rupture appears in the revolutionary bubble once one realizes that the Big Data so often lauded is actually only the structured 20% of data and major decisions are being made on such incomplete data analysis. What about the other 80% of data?

So while structured data is the 200lb. gorilla in the room, it is dwarfed by unstructured data – the unseemly, difficult 800lb. gorilla that ought to be tended to. That unstructured data includes messy, text-heavy information and emotionally driven information in the form of images, video, reviews, etc. In our social media era, that information is disseminated and translates as Posts and Re-posts, Pins, Shares, Likes and Chats. It seems the ultimate prize remains for those able to decipher the 'unstructured data' – that 80% of **everything: the most personal, subjective and powerful** information upon which we act. The value of emotional data in marketing is widely recognized. So, "What is emotion? It is the modification of neural activity that animates and focuses mental activity." (Wilson 1998) The strategic function of emotionally enhanced data is beginning to be adopted by those most driven by innovation (Muller 2003). 'Animating and focusing mental activity' in strategic decisions is the difference between those who innovate and those who do not.

Emotional content and meaning must be deciphered; intent must be revealed. That will require going deep and thinking slow (Kahneman 2011).

In June of 2012, there was a lot of buzz around research results coming out of Google's 'X Labs'. In an effort to simulate human interpretive learning, they exposed a network of processors to millions of images and then parsed the data to reveal that the computer could recognize human faces, forms and... cats. As extraordinary as that is... it doesn't help us much. We can recognize cats all by ourselves. What we cannot do is, based on one image (say the Barcelona Chair in the Barcelona Pavilion) find all other images on the net that are related to it, not by name or tag but by visual information. Even new things unrelated to content could be revealed: proportion, image density, composition, contrast, etc. This tool could further help in the associative/interpretive exercise and push creative thought further by augmenting the brains ability to access the shared database of the global internet.

Here's where Google could help, although someone else may be better poised to do so (perhaps Adobe will be the leader here). There are relationships amongst images that even most designers cannot recognize. Those quantitative relationships could reveal additional correlations. Advances in image parsing could allow us to browse visual data based on metrics including, for example, shape affinity, image density, edge definition, text regions, hue, saturation, exposure, structure, resolution and perhaps hundreds of other qualities. A long overdue tool, the image search engine will let us browse images, not descriptions of images but an image/metrics based browser. The results would deliver discriminative probabilities. Every image would have an algorithmic fingerprint that would then be compared to other images' algorithmic fingerprints to discriminate amongst the datasets and return likeness values and probabilities. The recent technological possibility to share images and movies has changed everything. As we move from word to image, this tool is desperately needed. A parametric, algorithmic description of the selected images is put through all images that share the same or similar data set for results. Quantifiable images will return expected and unexpected results – and reveal similarities that we understand perceptually but cannot quantify. Ideally that image data would take on

the additional search data every time it was selected as 'correct' by an interpretive human, further adding to and refining the descriptive image data. This process continues, eliciting a seamless human interpretation/ data processing synthesis could be initiated indefinitely. Each iteration reveals new meaning and redefines the meaning of the previous subset. We are engaging in what Pierce called infinite semiosis – a digital mimicry of infinite semiosis (Eco 1996). The revelations await.

It is expected of Big Data's meta-info that there must be a mega meaning, deep meaning. That is exactly what Google is trying to achieve with its cat recognition software (Dean 2012). As humans, we are excellent at going deep and thinking slowly. That may sound like quite a handicap in the face of extraordinary technology; but even a human baby can identify a cat in less than three days. In fact, a baby can identify millions of cats by having only ever seen one – as opposed to having to 'see' millions of cats in order to identify one. This fact is telling; it appears the best analytic tools for interpreting the unstructured 80% are human minds. Crucial to creating a meaningful Big Data field from which to make informed decisions will be the synthesis of machine and human analytics. Per Cukier and Mayer-Schoenberger, "Behavioral economics has shown that humans are conditioned to see causes even where none exist. So we need to be particularly on guard to prevent our cognitive biases from deluding us; sometimes, we just have to let the data speak." (Cukier, Mayer-Schoenberger 2013) It seems humans are notorious for seeing meaning where there is none and machines are notorious for seeing no meaning where there is plenty. While structured data may correlate with change, non-structured (meaningful) data creates change. Getting at that meaning is everything.

### **Revealing the Meaning of 80% of Everything**

Business typically looks for relative meaning: meaning as it relates to buying patterns, entertainment choices, politics or economics: "...one of the most important factors in social activity is meaning and change in meaning –" (Osgood 1975) There are many who focus on the business of meaning. Criminologists, Analysts of all types and those engaged in taking polls and marketing all share a common desire to predict behaviors. There are new measurements of meaning emerging. The latest tools though, are still far from being able to decipher

and interpret meaning. So the question remains, how can we get to the meaning of 80% of everything? If “the meaning of a sign has been defined as a representational mediation process, a complex reaction divisible into some unknown but infinite number of components.” (Charles Osgood, *The measurement of meaning* p. 31), then designers are uniquely suited to interpret the data of meaning.

Let us define Design simply as a process that gives form or representation to ideas. That definition presupposes three things: ideas → process → representation. Design though, is much more complex than that definition suggests due to the richness and the implementation of the process. Ideas are informed by data. That data is perceived, translated and interpreted for meaning to become an idea. Ideas must be abstracted and contextualized to become comprehensible. Once an idea is comprehended a constructive skill set is necessary to create a representation. Once an idea is represented, meanings can be gleaned from it. From those meanings, knowledge or understanding can be achieved. From that knowledge, we are able to make choices and decisions:

data → →perception → →translation →  
→interpretation/meaning → →ideas → →abstraction  
→ →contextualization → →comprehension/meaning →  
→ applied skills → →representation → →meaning → →  
knowledge/understanding → →choice.

This process is called ideation and is assumed to spend most of its time in the brain as a cognitive process – a creative cognitive process. But how do we know it exists? Skinner cites Bloomfield, ‘...the only evidence for the mental processes is the linguistic process’ (Skinner 1948). I suggest, as we move from text to image in our communications, the image, review, ranking, video, or meme is also evidence of mental processes. The cognitive events that occur during these processes require skills to externalize, articulate and introduce into a social semiotic system (Coles 1999). Once these representations have taken their places in our social fabric they are either afforded acceptance – or not. If a product is deemed ‘ahead of its time’, usually that means the structure of the receiving environment recognizes the value of the product but social, economic or cultural zeitgeist, does not afford a place for it within the social fabric. There was not a place for that idea to enter into

the structure/system. It bounces around as an anomaly without the associative meanings of other ideas to ground it. But systems shift & opportunities reveal themselves through inevitable changes in society and time. Designers can intervene in the system and design the groundwork of associative meaning structures, anticipating the introduction of the represented idea and improving the likelihood of timely acceptance.

Humans process perceptual sensory input through abstraction, reduction, association and synthesis. We often call this thinking. Thinking assumes varied and highly developed sensors, massive processing power, a phenomenal database of stored reference data and a capacity for articulating the result of the process. The right brain and subjective ordering processes happen so quickly and on so many levels simultaneously that it is impossible to quantify the process. Even more difficult if the goal is to synthesize what millions are thinking. Yet, as in affinity diagramming (Ulrich 2003) if we can extract the most prominent ideas from the group, take them out of the mind and engage in a simulated version of thinking by delineating the most prominent ideas we have a brainstorming session. Representing ideas visually is crucial to achieving the emergent qualities similar to thinking. Therefore, the representation of ideas and the structure/process of articulating them shape the potential for emergent concepts in a group setting. The desire to discover order and facilitate change is often what draws a group to the creative process. Because the process has a structure, the degree of affinity between the emergent results and the initial condition can be steered based on the parameters of the process. Through the designed creative process, subtly-progressive, or radically-disruptive change can be achieved. Now what if that process can act in a billion minds simultaneously?

We discover is that the definition of Design should look more like this: data → process → ideas →process → representation. Within each process phase there exists the work of resolving for degrees of meaning. The component elements of meaning are assimilated through the advancement process of design and the meaning gets richer as it evolves towards conclusion (Eco 1994). Once a design is concluded, the representation takes on additional/other meanings as it is introduced into the system and adopted by society. Those meanings

are dynamic and decisions based on them affect society and culture. The conceptual framework for creating knowledge grows out of culture (Cetina 2009) and knowledge gained is reintroduced, and so on... forever.

What though, is that initial data that catalyzes the design process? Stimuli taken in through sensory integration, is the data of perception. In order to assign meaning to data, we must first be able to perceive it. The working definition of Perception as "the organization, identification, and interpretation of sensory information in order to represent and understand the environment (Schacter 2009)" will serve to frame the skills of perception. We can perceive much more than external stimuli and as this data becomes information, the process of giving it meaning creates associations with other sensory input. "Much of the input to the brain does not come from the outside world but from internal body sensors that monitor the state of respiration, heartbeat, digestion, and other physiological activities. The flood of 'gut feeling' that results is blended with rational thought..." (Wilson 1998). There is no meaning without the synthesis of stimulus data with emotional, contextual and intuitive data.

The Big Analytics of structured data are attempting to squeeze the 'gut feeling' out of decision making. The danger there is that "without the stimulus and guidance of emotion, rational thought slows and disintegrates (Wilson 1998). Rational decision-making based on the numbers is valuable and especially important for the maintain & grow progression of business but deadly for the lucrative and catalytic and discover & innovate core – innovation needs the gut. The "...five discovery skills of disruptive innovators: questioning, observing, networking, experimenting, associating (Gregersen, Dyer 2011)." cannot be sufficiently achieved through Big Analytics. Decisions are most fruitful when the 'numbers' are combined with intuitive wisdom gained through experience (Benjamin 1985).

It is generally agreed that intuition is a type of knowledge (Bohm, Peat 2000). For many, it becomes unsettling to recognize this knowledge exists; and it can be acquired stealthily. The product of perception and experience, intuition is often seen as something somehow supernatural (Feuerstein 2008), or worse – feminine. Big Analytics argues that intuition is nothing

upon which to be basing business decisions. Great minds have indicated the contrary: "The workings of intuition transcend those of the intellect, and as is well known, innovation is often a triumph of intuition over logic." (Holton 1997)

Intuition is knowledge based on highly developed skills of perception. Persons described as very perceptive are also often described as highly creative. Jung described the highly communicative and intuitive as likely to be entrepreneurs or revolutionaries (Jung 1971). The designer is constantly absorbing meaningful data from the environment, sifting through it, recognizing similar information subsets in that data and revealing potential for innovation based on meaning. This perceptive process happens extremely quickly and many perceptive occur simultaneously. The process itself is interpretive. Regardless of whether perceptive data is experienced directly or transmitted through social media, those experienced in processing sensory data are able to that process to the point it becomes automatic and subconscious. Active thought can then be dedicated to higher-level analysis of sensory information. That is what distinguishes the trained designer from the novice designer.

**An example:** All data perceived and represented has a design. There is always some order, even if we cannot define exactly what it is. Why, for example do Tara Donovan's works get adopted to represent elusive concepts like strategy (HBR 2013)? Her work has an obvious material order to it. The order is immediately recognizable, although the overall form is unclear – or at least open to interpretation. Perhaps we just want it to have meaning/association where there is none or perhaps there is plenty. Humans tend want to order information. If that be the case, and all humans are doing it... it must be worth designing for.

### **Data without Design**

Big Data does not have a plan. It is just data – data without, context, without emotion, without intuition, without culture, without meaning, without design. How do we look at this data? How do we find what it could tell us?

Just as we have structured and unstructured data; we also have structured and unstructured observations of data. The analysis of Big Data is undifferentiated. It is looking at everything in the hopes of discerning patterns or

behaviors. Once particular behavioral patterns are exposed, a more differentiated structural analysis can begin. It is the difference between looking at particular behaviors to get answers to particular questions and taking in a wide set of behaviors to perhaps reveal a pattern that could suggest the question.

The tools for parsing this data are woefully lacking. The motivation for those persons analyzing big data is to get objective information. It's the data of desire they want to get away from. Intuition is unreliable. Removing 'gut feel' from the decision making process and basing decisions on hard data provides reassurance and a way to shift responsibility away from the decision maker. But doesn't innovation come from the gut? Aren't we always trying to add emotion to convey more accurate meaning? Be it the richer information of images, reviews, video, music, emoticons, or memes shared in lieu of, or in addition to text, the desire to convey deeper meaning is pervasive. Adapting to posting multi-sensory data in order to convey ideas as we move from the word to the image has been made easy through social media. Analyzing data without interpreting emotional content is, at best, a stab in the dark at meaning. If we need structured data to drive our decisions, strategic moves and innovations, how is it that the most innovative new communication platforms, tools and liaison structures, came into being. Where is the data set driving the development of the Iphone, Amazon, Facebook, Twitter or Pinterest? It seems making decisions based on the "gut feel" of unstructured data is not only a good idea it is a game changer on a global scale. To the designer though, unstructured data is an oxymoron.

**Big Data needs a strategy.** Big Analysis requires fewer resources as processing and retrieving data becomes less expensive. Leveraging Big Data has become the biggest game in town and in order to stay competitive, business must play. Deciding what big data should tell you is half the battle and the point where a creative strategy must come into place. Creative Strategy benefits from Think Fast, Then Slow (Kahneman 2011). Big Data can think fast but cannot go deep; the samples at hand are very broad and undistinguished. Specific questions about specific groups cannot be answered. The data set is too wide and shallow. You may though, by thinking fast, discover areas worth going deep into and re-specify your data collection efforts to get

to deep meaning. Going deep creates value.

Designers have mastered the tools for going deep. To design is to get into the details and simulate, assimilate, digest, decipher, and ingest massive amounts of data in the process of reaching a solution. "Once we datafy things, we can transform their purpose and turn the information into new forms of value." (Cukier, Mayer-Schoenberger 2013) Both quantified and qualified datafication are necessary to maximize value potential.

As complex as the design process may seem, most of it occurs under radar and there are few discernible steps in the path from inception to production. The way a tool looks and its ease of use determines its survival. By getting designers on board at the incipient strategy stage, business can improve products and the likelihood of user acceptance. If business proceeds without including designers early in the process, they will likely spend resources trying to fix their product, network or interface along the way. Fixing can be expensive and sometimes businesses make the curve through re-branding and redesigning. But more often, the consequence of not having designers on board early is a super-expensive, awkward... something or other... without a place in the world. Designers are the professionals who can transition the undifferentiated data feed through the cultural semiotic hive and create new structures, representations, forms and products for business and commerce. It is critical to success to design as you go.

### **Whole Data Research with Design**

Big Data feigns satisfaction with quantitative methodologies to analyze data. The complex analytics now possible allow relationships amongst relationships of data to be analyzed and correlation amongst numerous phenomena to be revealed; all without understanding causality and while disregarding 80% of all data out there. The whole data research (including both structured and non-structured data) emerging in Design is changing perceptions of design research from 'soft' science to 'solid' science. Advanced technology tools enable the augmentation of quantitative operations with descriptive qualitative elements to enhance the meaning of the whole data set. Always focused on behavioral meaning in social relationships; the qualitative research, in order to measure itself, is developing quantitative artifacts as markers and indicators.

Apps have allowed people to act as agents of social interaction, define value systems, modify behavior. They also have, unlike big data, a welcome, defined scope which provides empirical data to shape the 'soft' data. Apps can be monitored while in use, on the move and within their geographical context. Analyzing App data allows researchers to get intimate proximity to those being studied without being intrusive. This new modality of Whole Data Research is providing a yet unheard-of proximity of study. As a parameter of good research we engage in 100% natural observation – direct and immediate contrasted to a selected test group in an artificial environment. What might be the value of such market research?

The most notable advantage is the opportunity to study the way particular environments affects behaviors. We now have a variable of place and movement – contextual data to add to the mix. An ever more complex and differentiated whole data set emerges. Through app research, many kinds of observational studies are possible simultaneously (cohort, self-reporting diary studies, ethnographic, mechanical, photographic, disguised, randomized, etc.) which lends to an efficiency in data analysis and doing more with less. It is possible to get very individualized information and draw and redraw test groups based on ever more distinguishing parameters. Example: What are the patterns of apparel purchasing do followers of a DIY Pinterest board who also use Tumblr and Twitter, have the Etsy, Dwell, Cnn, Amazon, Mint.com apps, a walkmeter and at least two preschool learning games installed and post images of kids on facebook? Where can I find them in order to direct market my new line of hand-made organic hemp accessories? How much will they likely pay for my product? This form of research takes advantage of directly applicable and quantifiable demographics. Traditional demographic categories are nullified. The action of customizing devices with apps achieves a higher level of individualization for each user. Demographic subsets defined along traditional categories no longer satisfactorily indicates behavior. The data of race, gender or class is now largely irrelevant in the face of the richness of the more telling data. The Whole Data combination of Structured and Unstructured data analysis is necessary to reach the most meaningful answers.

An unprecedented penetration of communication and entertainment technologies has changed the nature of social relationships and interactions. Movement and proximity once strong indicators of relationships are being redefined. "The assertion of social spatiality shatters the traditional dualism [of physical and mental space] and forces a major reinterpretation of the materiality of space, time, and being..." "...not only are the spaces of nature and cognition incorporated into the social production of spatiality, they are significantly transformed in the process (Soja 1989)." One may sit next to the same individuals every day on the train but feel his/her primary community consists of people with whom one has chosen to interface. Perhaps it is a group sharing results of the same marathon training app or parents who choose to home-school or even people with unusual hobbies.

Space has, through social media, crossed that anticipated threshold where the spaces our bodies inhabit are more or less interchangeable as our social spaces become more defined (Tuan 1977). Through the ability to customize interface aesthetics and tools to reflect desires; personal space is now personal interface. Home is still where the heart is; and the heart is with the device. Interpretation of this hyper-personal space requires cultural understanding. This is where computers again fail... so far. It is another example of the necessity for collaboration between computerized big data analysis and the interpretive analysis of cultural researchers. Setting up a design research strategy to facilitate an overall data strategy is essential and identifying the appropriate tactics and techniques to get the best results is conditional to success (Zenger 2013).

A bottom-up (constructive) processing of sensory information: lines define regions, regions define shapes, shapes suggest forms – is largely programmable and we should allow the computers to do it. It is the top-down (deconstructive) processing of expectations and associations based on experiences that we must still leave to the humans. Experience presupposes knowledge. Designers act as intermediaries and interpreters of unstructured data. Design innovation is knowledge often based on the 'unstructured' data, which if we believe IBM and others, is 80% of all data. One could say the lion's share is embraced by designers

and derided by those trying to teach computers to decipher the noisy text and emotional content of images. Design knowledge is attained through perceptive experience. The richest data is culturally and sub-culturally specific, dynamic, catalytic and flies in the face of parametric big data in terms of impact and potential for innovation. Attempts to structure the unstructured data through text analytics or tagging with meta-data are attempts to create a perception machine. Those savvy enough to seize the opportunities revealed through whole design research to gain design knowledge will be best poised to innovate.

### **Big Social Media Ontology**

How agile we are in social networks in America has much to do with cultural bias, technological user literacy, communication effectiveness, access to fast networks, age and to some extent gender. It has surprisingly little to do with income, education level, or race. In the US nearly 70% of those on the internet are users of social media. (Duggan, Brenner, Pew 2013). In the face of such proliferation, it merits the question, what is the nature of being/reality in social media? What is our social media ontology? The question is of course philosophical and the relevance of the answer lies in our ability to use that answer to direct whole data research.

It is fitting to frame the philosophical question as an existential one. In social media we see the key components of the individual as the thinking, perceiving, experiencing center in the quest for knowledge and meaning in an absurd world (Crowell 2004). Most relevant to question of 'being' in social media is the concept of Agency. Social media interfaces are mediated spaces (Thompson 1995). Those spaces are contextual avatars, representing the self and the context surrounding one's self. For many it is the edited version of themselves; and for many (often much to their chagrin) it is the unedited version of themselves. This agency gives the individual a moment to think before acting. It is an opportunity for self-reflection and to anticipate how the mediated public interface will be interpreted by friends and society at large.

Creating the agency through images and shared information is a design process. Social media allows the individual to deliberately act covertly or overtly in order to promote a public perception, image or status

(Vygotsky, Cole 1978). There exists a split awareness when designing a personal social media interface. The awareness of the complete self and all the information and artifacts that could describe that self; and the curated interface that has been selected to represent the most advantageous information and artifacts. There is a potential stress of disconnect between the complete self and the curated self. "In summary, then, covert behavior is behavior which (1) is effective upon the speaker himself and (2) avoids the consequences of the overt form. "But a considerable reinforcement survives in verbal behavior at the covert level because may be his own listener and may reinforce his own behavior in many ways... In general then, when talking to oneself, it is unnecessary to talk aloud and easier not to (Skinner 1948)."

### **There were once distinct spaces for commerce, entertainment, communication and politics – and distinct behaviors appropriate to those spaces.**

Through social media, commerce, networking and both image and written communication travel along the same networks (Lefebvre 1991). To limit one is to limit them all. To heavily curate one demands curating the others in order to achieve consistency and credibility. It is a Sisyphus battle to try and censor political exchanges from the top down while promoting commerce and entertainment. Social media may provide a commercial motivation for more exchanges and less censorship. This is a double edged sword and revolutions have been coordinated through Twitter. It would be easier to change your politics/policies/ruler than to change the potential for Twitter to facilitate a protest.

Social media facilitated revolutions can be also revolutions for good: improving health, protecting the environment, etc. Whether for consumption or conservation; social media serves all masters equally. So the question is, who can most affect society and identity? What is the most convincing/appealing argument? What does that argument look like? What are the tools of getting buy-in/sympathy/emotion and action? How do you create/design desire? How do you keep it from going radical? Stability comes through the sheer vastness of social media. Having many divergent opinions rather than one strong voice insures that society remain fragmented and peaceful and busy customizing their commerce, entertainment, political and communication experience.

### **The Data-fied Self: Interfacing in Social Space**

Be it Nike Training, Mind Training, Fitbit or the UP self-monitoring bracelet made by VC backed Jawbone, tools and apps to link personal diagnostics (heart rate, sleep patterns, weight, exercise routine) to a mobile device are prolific. According to the Pew Internet & American Life Poll, 60 % of Americans track health related data (Pew Research 2012). This is an example of the quantified-self movement (Wolf 2009); a hereto unprecedented connection of the personal biology through the interface of clothing/accessories and apps to a mobile device. The apps and devices are linked to social media and metrics are shared with the intent of modifying behavior through feedback, reminders and social pressure.

The once radically progressive technology of connecting a functioning pacemaker directly to the phone jack to send diagnostics, now seems antiquated. In the 21st Century, wearables send diagnostics remotely and in real time and are worn more or less visibly. Even the big players have recognized this booming market and are getting in on the game (Kharif 2013). That 'internet of everything' or "Total Information Awareness (Reaves 2002)" we keep hearing about includes sleep rhythms, blood sugar levels, frequency and intensity of physical activity. The self-monitoring and self-diagnostic offerings are growing and will be the next step in the seamless integration of individual and internet. For designers, the question posed is how to design the experience of being watched? What is the experience interface, the experience of alerts, alarms and feedback? How do we design the motivators of behavior modification; the reward experience, the sharing experience? In order to answer these questions designers must engage in processes that facilitate acting as agents of the user relative to a product, idea or service. Breaking down the user experience into micro-moments or selecting a wide variety of users and depicting their interaction through agency becomes a strong tool in the strategy development tool box. This is agent based design through the UX (user experience) scenario process: a user-based design process. "...Combining big data, behavioral targeting...mobile devices and GPS..." [as a research methodology, designers can set up a framework to get direct access to behaviors], "...application developers can design more effective

operant conditioning environments and keep us in virtual skinner boxes as long as we have a smart phone in our pockets (Davidow 2013)". The data collection can occur over long periods of time in a non-invasive manner.

Designing for numerous interactions in a day with social media requires a different approach that traditional design of objects or artifacts. Design must be conceived as perpetual and participatory. The experience of the same interface changes in the space of moments. The instant and interface of desire must be designed. The user experience becomes the roadmap for a design strategy. All touchpoints are analyzed, interpreted, designed and tested through numerous scenarios to insure a responsive interactive, customized experience. This approach is common in marketing and advertising; a focus on behavioral phenomena to create an experience around a product. For the experience of personal monitoring to affect behavior, the micro-incremental moments of desire must be anticipated. What does it feel like to 'like', pin', 'tweet', 'post', 'view' etc.? – Is there a tangible or perceptual usefulness in the experience of quantifying oneself? Do the benefits outweigh the vulnerabilities that come with sharing such personal information? Does the user find the tools for doing so - valuable? In a time where exhibiting hyper-extroverted qualities is seen as the new ideal personality type (Cain 2012) everything is spontaneous, everyone is watching, sharing and commenting. "Social media further swells the potential for 'being outgoing' or, more positively, provides a place to be extroverted for those who are otherwise quiet.

### **Mass Customization & Device Topology**

As we wear our devices and sync them to our physical bodies and social minds they become not just an extension of ourselves – but a physical part of our perceptive apparatus. We are aware of the proximity of our devices at all times and are conscious when they are not behaving predictably; or worse, lost. We can customize our phones to vibrate, sing, or play a tune depending on the caller or the appropriateness of device use at a particular time or place. We have a proprioceptive sense of the physical position and movement of our devices as well as its language of communication: it reminds, rings and speaks. We have 'taught' it to do those things according to our own preferences. Through acoustic and visual modifications

as well as performative modifications, through adding apps, layer upon layer; every device becomes one of a kind and specific to its user. Such mass customization of a widely-adopted tool is unprecedented in history.

The proliferation of smart devices is largely due to the combination of fetish and utility. Owning such a device is gratifying in that it satisfies the desire for beauty, represents status and justifies ownership based on functionality. The devices particularly serve the individual who has invested large amounts of time customizing and carefully defining the parameters of its utility: purchase a platform – curate its use (Monroy-Hernandez, Resnick 2010). As the users engage in the process of customization of his/her smart devices, they consider personal preferences as well as geographical and situational factors. The assemblage of apps on any person's device define the user as much as the user defines the tools. By selecting particular apps the user chooses to interact with them – to behave in a particular manner.

The intricacies of an individual's personal experience though is becoming ever more particular through the selection and customization of interfaces aesthetics, tools and media sources. The simple act of choosing a selection of particular news feeds causes realities to differentiate. Reality and truth, not just across cultures but across the table can vary radically. Not that long ago, the news was presented in thirty minutes. Now the expectation of information is much higher and users of media thirst for many different types of unstructured data to create their own truth about any event. Achieving comprehension of any news event is much more differentiated and biased. We can choose to view information in the way we want to have it. Having the facts reinforce an opinion has always been desirable and now it is achievable through customized, selected information interfaces. Since experience is a type of knowledge and we can customize our experiences; the person doing the knowing can be customized. Designing the experience is designing the person = Behavioral Change. The designed experience has become a commodity (Pine, Gilmore 1999). We now design for behavioral change.

#### **The power of customization assures longevity.**

The adaptability of the platform and the ability to build upon previously selected tools while removing ones that

do not work, sustain interest and add value to the device. The state of the platform/tools union at any given time is **Device Topology**.

Doreen Massey's 'layers of investment refer to a changing spatial structure defined by layers of investment, and therefore activity in building etc. through time. As each layer is put into place, it interacts in a sort of fluid terrain model with the layers before (beneath) and becomes ever more differentiated and particular with each layer over time. These layers of investment were explored in relation to division of labor but interesting insights can be drawn when using this analogy to describe the platform and the investment in geographic and situation-specific apps added to serve the functions desired on an individual level. Like in Massey's discussion, the apps and the platform have a 'mutual determination' each giving and shaping the other's meaning (Massey 1984).

Especially interesting is the impact of local personal, geographical and situational forces is considered as well as the relevance of non-local, external but relevant forces – meta forces. At the scale of each individual, mass-customization is performed relevant to his/her value system. The value of a person's value system is very high, particularly when trying to predict, elicit, or modify behavior – the great desire of commerce, politics, and entertainment. The adaptability of the 'purchase a platform – curate its use' service/product insures the longevity since it breaks down the demographic market definitions. Everyone is the market. Whether you are a field journalist for CNN, a teacher in a community preschool or an aspiring Olympic athlete, this tool was made especially for you – and you cannot do without it. You make it meaningful.

#### **Emergence of the HiveDesign**

To initiate discussion on the emergence of hive-design, it would be beneficial restate the premises thus far:

- **Big Data** is a vast collection of quantifiable but meaningless data parsed by computers to reveal correlations.
- **Soft/unquantifiable data** is four times as big as Big Data and requires human minds to interpret.
- **Data without Design** is insufficient to make rich decisions
- **Whole Data Research** integrates structured and non/structured data and is the ideal information construct to generate the most valuable knowledge

- **Social Media Ontology** describes identity and existence as mediated through the agency of social media interfaces, presence and status
- **Interfacing and the Datafied Self** is the phenomena of self-monitoring and engaging in biological/technical interfacing through wearable technology
- **Mass Customization and Device Topology** describes creating value and longevity for the platform and tools by empowering individuals to personalize the performance of his/her device

**For the purposes of describing the phenomena of Hive design, we refer to major aspects of Jeffrey Goldstein's description of emergence:**

...the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems. Emergent phenomena are conceptualized as occurring on the macro level, in contrast to the micro-level components and processes out of which they arise. Certain interrelated, common properties identify phenomena as emergent:

- **radical novelty** – the phenomena cannot be predicted from the behavior of micro-level components
- **coherence** – emergents appear as integrated wholes maintaining a sense of identity over time
- **emergents act on the macro level above the micro level** of the associated components that engendered the emergence
- **emergents are dynamic and evolve in a complex system over time**
- **emergent phenomena reveal themselves** (Goldstein 1999)

HiveDesign is an emergent community of co-creators simultaneously working in a hyper-temporal (exchanges happening pervasively and concurrently) and hetero-temporal (perception of time varies relative to place) environmentally responsive space/time construct engendered by social media (Sha 2011). Individual creators make up the hive and may view themselves as fiercely independent. HiveDesign is open source, adaptive design and is practiced by both trained and novice designers (Florida 2002). The hive of designers is largely democratic and intuitively identifies its leaders – yet may deny being led. HiveDesign holds little allegiance and is fluid and reactive.

There is meaning in that movement (fluidity). How 'present' a user is and 'where' he/she can be found contributes to the profile and status of the user. The questions as to an individual's presence are common: 'Are you 'on' Facebook, Twitter, Tumblr, Pinterest, LinkedIn, or Google+?' The answers to those questions define social media presence. Within the hive of social media, users either move between these spaces or are 'on' them all simultaneously. If a user has been deemed inactive, social media will send email or text messages to motivate users to 'share what you know' or 'update your status'; which brings us to the importance of status.

"Status is central to all complex mammal societies, humanity included. To say that people generally seek status, whether by rank, class, or wealth, is to sum up a large part of the catalogue of human social behavior (Wilson 1998)". The agency of social media provides the novice and trained designer the opportunity to reflect on status and take action through re-assembling content and presence. "...Given that one's own character and worth will be partly read from the relations that one keeps, a desirable relationship may be displayed in proper and populous places for the purpose of establishing one's own value (Goffman 1971)." Recently, a student confided, "I'm so worried about my friend, she changed her Facebook page and everything." She obviously feared that there had been an existential rupture in her friend; a fear that the change in social media status was so fundamental that it could change the nature of their friendship. That was five years ago and it has become expected to change your status in order to be actively engaging with your social network.

The individual designers of the hive consistently and intuitively conduct design research through experiments in expectation. Social media platforms allow users to 'try-out' different versions of the self through the agency of the interface. Users can create and recreate themselves through changing profile pictures, adding and deleting friends, changing feed subscriptions and using different apps. If the curated content of the interface agent doesn't get the desired results; the user can rebrand him or herself as often as he or she may choose. The effect of rapidly revamping our customized agents is the depletion of the value of personal data. Even the most revealing information can be made irrelevant/obsolete at any moment in the manner

of 'that was so five minutes ago'. The correlation between value and meaning also indicates that the possibility of rapid reinvention also strips the data of meaning. The process of making identity includes the informational purge – we can reinvent ourselves by changing our apps. This process is adaptive customization.

Followers of Saussure and Pierce can agree that meaning is derived through relationships. Our new media tools enable Piercian unlimited/infinite semiosis (which implies the deepening of meaning). Eco refers to Hermetic Drift or Neoplastic Growth to describe "...the uncontrolled ability to shift from meaning to meaning, from similarity to similarity, from a connection to another." (Eco 1994). Meaning changes and evolves in, and out of, this situation. Through sharing, repinning and reposting blogs, images, video, reviews, articles, quotes and memes through social media, the hive of designers is effectively engaging in both infinite semiosis and Hermetic drift. For example, by quantifying the interpretation of images through adding hashtags (#) as images are shared, more and more information can be associated with an image.

Infinite semiotic growth is what we experience with the pinning, posting, tagging and sharing now possible through our apps, devices and social networks. Every individual that passes the information along takes it out of context and makes new associations... a kind of hive interpretation, hive design. Depending on cultural background, experiences and community, meaning can be something very different from one interpreter to another. If though we are sharing the same tools and acting in the same hive, our common tools and common platforms provide common experiences and more common meanings that allow design to reach a broader audience, on a superficial level. If one of the interpreters in the hive finds a 'share' irrelevant, it will not be passed on and dies en route unless someone else picks it up and shares it further (Asur, Huberman, Szabo, Wang 2011). The hashtags: #Taj, #India, #Beautiful → repinned as #white, #my dreamhouse, #vacation → again repined as #mausoleum, #architecture, #stone, and again → #tourist trap, #Bollywood, #bright. This is HiveDesign engaged in Pierce's 'infinite semiosis': repinning and hashtagging to deeper meaning. Typically, there is little interest in the original meaning of the catalyst image (Barthes 1977). For some though,

greater information can be gleaned by delving deeper into meaning through correlating new images and the plethora of associated hashtags to develop a richer overall comprehension/knowledge. These new social media sharing parameters are an unexpected and astoundingly deep cradle of information available to design research.

### **Strategic Co-opting of HiveDesign**

Benefitting from hivedesign requires skills in crowd-sourcing. Enlisting hive-designers to contribute interpretations from the 80% of unstructured data in order to add to the Big Data mix and approach 'whole data' evaluation as a basis for decision-making is the big idea. Recognizing that soft data has profound value and making the choice to leverage the meaning of that data is the key to innovation. Interactions in social media are always making meaning, consciously or not. Part of a successful Whole Data Strategy includes a method for harvesting knowledge from the field of social media. The sheer volume of quantification through interpretation being carried out by the novice and trained designers in social space demands attention. Experienced design executives/professionals are uniquely qualified to develop the soft data interpretation strategy as a collaborator in the strategy development process. These design professionals can identify what is rare, distinctive, well-represented and valuable as well as design the modalities to enlist and engage hivedesigners in order to steer more focused results. Hivedesigners can provide answers to such questions as, Why do we click, follow, or share? What are the indices that signal a pattern? How are ideas categorized thematically and who are the thematic neighbors (competitors and collaborators)? Hivedesigners provide opportunities to covertly experiment with small scale implementations of new strategies, prepare & manipulate visual content. Hivedesigners can source content and decipher bias of reviews from amazon or yelp. The Return on Investment is impossible to quantify.

Once patterns and structures have been identified from the hivedesign data, a design strategy team engages in Dynamic Semiotic Analysis to decipher meaning relative to identified goals. The dynamic semiotic analysis process happens in the midst of the activity it is studying and evaluates meaning based on micro-components of time, place, culture, interface, aesthetic

and experience. A design strategy team can, based on the results of the soft data research provide orientation in an ever evolving social media and interactive world. Designers can quickly share this information through data visualization and agent simulation in order to heighten institutional intelligence by letting all players in on 'where' the strategy is heading. It can improve the entire organization's strategy sophistication by providing the opportunity to experience information rather than to simply see it.

By engaging a larger body of the organization and having decision makers become party to the analytics; deciding which questions to ask and evaluating risk assessment are seamlessly integrated into the overall strategy. Through a durable soft-data strategy built on an aesthetic, temporal and cultural semiotic knowledge base, more (and less) desirable experience paths can be designed with the intent to guide choice.

"In the 1930's BR Skinner developed the concept of operant conditioning... we now know how to design cue, activity and reward systems to more effectively leverage our brain chemistry and program human behavior (Davidow 2013)". Once highly controversial, the practice is de rigueur eighty years later and it has been shown that consumers are not adverse to this type of 'native' advertising provided the content provides a valuable experience. Users recognize that they are affected by their experiences and choose to be affected by appealing experiences. It is for the designer to create that appealing experience. Designing the experience is designing the person. This is the added value behind design. Organizations with a well-developed whole data and creative content strategy will be adept at influencing behavior – and will be the innovators of the future.

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# Designing to Scale: Social Relations Design

## Abstract

Social relations and networks have changed so rapidly, and to such an extent, that we all see, experience, and interact with our communities in different ways and on different scales. Within such a haphazard environment, social design's objective to create positive change is unquestionably commendable. However, such change is problematic to sustain without a coherent methodology and strategy and it can be argued that social design, as an explicit approach, is still in the process of developing these. This article suggests that by promoting a design focus at the scale of social relations, both in terms of objectives (reducing social disparity) and strategy (focusing on social relations), social design can make a more effective and sustainable community contribution. To examine the potential of this approach, the article introduces a conceptual process model to help visualize how inequality operates. Using this model, examples of successful social design projects are considered to explore how social relations may have been positively impacted in the various contexts. Due to the complexity of the concept of inequality, the issue of working at simultaneous scales (external and internal to the community) is recognized as an important factor in a social relations design approach, as is a commitment to place-specific sustainable change.

## Keywords

Social design, social relations, inequality, scale, community design, context

## 1 Introduction

Simmons [2011, 3] observes that “[d]esigners frequently describe themselves as ‘problem-solvers’. We apply our creative talents to finding new and appropriately innovative solutions.” What if part of the problem is finding the right problem? Globalization has cultivated and complicated our social networks and relations to such an extent that we all see and interact with different problems at different scales. Within such a haphazard environment, social design's objective to create positive change is unquestionably commendable. However, such change is problematic to sustain without a coherent methodology and strategy and it can be argued that social design, as an explicit approach, is still in the process of developing these.

This article suggests that by creating a focus, both in terms of objectives and strategy, social design can make a more effective contribution. The objective is the disruption of social inequality and the strategy is a concentration at the scale of uneven social relations. The scope of this article does not allow for a comprehensive discussion of methodology, especially of co-design, which is seen as an integral element (see Sanders and Stappers (2008) and DiSalvo et al (2011), but it does make reference to the various tools that are often utilized in social design. As all social relations operate within an instrumental context, this approach will also need to consider this ‘external’ scale as well.

This concern of operating at simultaneous scales is a challenge that is discussed later in the article.

The first section introduces the characteristics (objectives and tools) of social design from a selection of contemporary design literature. The intention is not to attempt a definition of the concept but rather to establish a broad understanding of what it is. The following section introduces a brief conceptual process model of inequality to propose that a social relations design approach should isolate the mechanisms of the process to create discrete points of focus. Finally, project examples highlight elements of social relations design within them in an attempt to illustrate its potential contribution.

## 2 What is Social Design?

Any attempt to categorize social (or socially responsible) design can be argued to be futile as the scope of design that influences the social sphere is both dynamic and multidimensional. As Faud-Luke [2009, 1-2] suggests, “[i]t seems design is difficult to pin down and is everywhere... Design is manifest in all facets of contemporary life.” Consequently, this paper makes no attempt to define the concept but rather suggests a new and particular social design focus (social relations design) that can produce positive, sustainable and efficient outcomes. However, it is useful to first comment on the characteristics attributed to the term of social design. These characteristics can be viewed in two categories: objectives and tools.

### 2.1 Objectives

Social Design is about innovative approaches driven by a commitment to positive change, social equality and environmental sustainability. It aims for transformational structural and systemic change that tackles the root causes of social marginalization and environmental deterioration through disruptive design thinking. Ingrid Burkett [2012], from the Centre of Social Impact, proposes that the focus,

*“Is on the design of products that benefit people (for example, the design of water purifiers for people living without potable water); or services (for example, designing more inclusive financial services); or processes (for example, designing participatory decision-making processes inside organizations).”*

Put simply, at the heart of social design is the pursuit for a better world. Responsible design seeks solutions and improvements to enhance people's lives and create a sustainable society by applying design principles to social issues. Faud-Luke [2009, 49] appreciates the extent of the undertaking and comments,

*“There is a growing need for new design heroes and heroines to provide some guidance to meet the enormity of the scale of the environmental, social and economic crises in the global, and regional/local, economies.”*

Shea [2012, 7] agrees and appeals for a shift in thinking, saying that “[s]ocial design defines a new kind of designer. It needs to be expansively conceived beyond trained designers to include end users and social participants. Social design cannot be a subspecialty of the design profession.” This is in line with Brown's belief that design has become too important to be left to designers: “innovation has become nothing less than a survival strategy.” [2010, 7]

Potentially social design could be criticized as having competing characteristics. On the one hand the approach is understood to be responsible and constructive, working with communities to achieve shared goals. Conversely, it is also discussed in terms of design activism, which Faud-Luke [2009] often describes as the deliberate generation of a counter-narrative to create disruption and ‘massive change’. These two faces of social design need not cancel each other however, as the struggle to achieve sustainable and positive change within the context of contemporary challenges often demands interruptive approaches. As Berman [2009, 1] concludes,

*“Designers have an essential social responsibility because design is at the core of the world's largest challenges... and solutions. Designers create so much of the world we live in, the things we consume, and the expectations we seek to fulfill. They shape what we see, what we use, and what we waste. Designers have enormous potential to influence how we engage with our world, and how we envision our future.”*

### 2.2 Tools

Many of the design tools associated with the approach cannot exclusively be claimed by social designers. They are used by design and development practitioners –

among others – but what is unique to social design is the convergence of these methods. The resultant combination is a response to Brown's appeal: "[w]hat we need now are new choices [2010, 3].

Social design innovation needs to be accessible and viable, so that generated ideas can be implemented by (and with) non-designers for the greatest impact. This can be achieved through a culture and process of storytelling and exploration or, in different situations, through observation, experience and research. This level of preparation is essential and is what IDEO's Human Centered Design Toolkit labels as the 'hearing' phase of the process. This refers to the concepts of facilitating and co-creation (or participatory or co-design), which have been long been discussed within development contexts. As Harris [2008, 703] says, "[a]lthough the rhetoric of partnership has been widely adopted, its implementation ranges from instrumental arrangements that perpetuate unequal power relationships and change little in practice, to 'authentic' relationships based on maturity and trust." Escobar [2012, 18] sees these authentic relationships as essential to any developmental interaction because "we are always immersed in a network of interactions which are at every instant the result of our biological and cultural histories. We necessarily co-create the world with others." Such a 'bottom-up' perspective requires that the interaction to be context-specific (or place-based) to ensure that the design outputs have people and location at the core of the empathetic collaboration, what Escobar [ibid, 6] calls "bringing people back into situations." This idea is also evident within the user-experience interface between design and human involvement, which Brown [2010, 94] labels the "customer journey."

Having outlined these characteristics, this article now suggests that a new social relations design approach, by using the same tools as outlined previously, can prove efficient and effective in achieving positive change. The focus is on the uneven social relations that result from the perpetuation of socio-economic and environmental disparity. The following sections explore how social relations design is able to focus on the isolated mechanisms that drive the process of inequality, leaving designers more capable of disrupting the process that creates disparity.

### 3 How Can Social Relations Design Impact Inequality?

This article argues that inequality needs to be a key focus for social design. To do this efficiently and effectively it is now proposed that a new approach, social relations design, be considered. The following sections consider the nature of inequality and social relations, and how these relationships can be made uneven as a result of the process of inequality. Finally, the notion of a social relations design is introduced and discussed.

As with social design, the notion of inequality is somewhat amorphous and consequently complicated to define. It is easier to answer the question, 'inequality of what?' The disparity of income and disparity is demonstrably connected to inequality in contexts such as education, well-being, housing and employment. Within these contexts are uneven social relations of, for example, gender, ethnicity and class that are the units of comparison. For the purpose of this article social relations are understood as relationships between individuals within a group, between groups, or between an individual and a group. The relations vary and are, as described by Marx (n.d., 92) below, connected to a context.

*"[S]ocial relations are just as much produced by men as linen, wax, etc. Social relations are closely bound up with productive forces. In acquiring new productive forces men change their mode of production; and in changing their mode of production, in changing the way of earning their living, they change all their social relations. The hand-mill gives you society with the feudal lord; the steam-mill society with the industrial capitalist."*

These social relations of production, as outlined in the Marxian sense above, refer to how people are related to the sphere of production as social classes and in socio-economic dependencies between themselves. The processes of inequality operate and are sustained within various contexts, not exclusively within a production framework. Social relationships also form in environmental, structural (for example, education and access to healthcare) and cultural contexts.

Partly as a consequence of globalization, these contextual spaces have become simultaneously smaller and larger (e.g. Google Earth and the Skype platform,

which offers localizations in over sixty different languages). Consequently, social relations have been transformed and these changes are evident in society's widening socio-economic disparity. It is suggested in this article that design can make a significant difference at the community scale of these uneven social relations.

Inequality can be argued to operate as a contextual process and is a consequence of internal and external pressures, which can be understood as a 'complex whole' [Cardoso, 1979]. This perspective requires a design response to the challenge of operating on simultaneous scales. As Jin Yong Kim (2012), President of the World Bank Group commented at the last Clinton Global Initiative's Annual Meeting, "[d]esigning for impact, I think, means taking seriously this issue of scale. Thinking about scale from the beginning is key." Design needs to rise to the challenge of engaging with both the contexts in which the relations occur and also the relations themselves.

Socio-economic disparity is too complex a process to be 'solved' by one overarching design approach, as there are various processes of inequalities, often culturally specific, operating at different scales that reinforce each other. The UN [2005, 136] support his, commenting that, as useful as community-based policy targeting can be for reducing inequality, "it should not become a substitute for universal coverage." Consequently a situation of inequality needs to be understood externally, as well as from within. As such, a social relations design approach requires a 'simultaneous-scale' approach to disrupt ongoing processes and create room for contextually-specific positive change. To achieve this it is necessary for a designer to articulate and visualize the mechanisms that play a role in creating and perpetuating inequality.

### 3.1 The Process of Inequality

For social designers to understand how place-specific inequality operates it is imperative to recognise social and cultural entities (e.g. an ethnic group or a socio-economic class) as existing within a matrix of social relations. Uneven relationships are unique to the context, for example a refugee community negotiating with a local council to access appropriate healthcare or lower socio-economic status communities living in highly-polluted environments due to nearby industry.

de Ferranti et al (2004, 7) suggest that a "pretense to an exhaustive discussion of the causes of inequality is thus a shortcut to failure" and while this section in no way seeks to construct a definitive understanding of the causes of inequality, it presents a simplistic conceptual process model (Figure 1) as a framework for a social design approach.

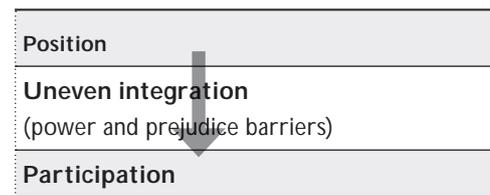


Fig. 1. A conceptual model of the process of socio-economic inequality

This process is understood from a structuralist perspective and is not designed to be operational but has been created to visualise the mechanisms that play a role in creating and perpetuating inequality. It is based upon the approach presented by Greig et al (2007, 13): "[i]nequalities are not simply carefully constructed measurements scales but complex webs of dynamic social relations that privilege some while constraining the life chances of others." To allow the consideration of the interplay between external and internal factors the model can be argued to sit within an 'external' environment (made up of geo-political, historical, economic, socio-cultural and environmental aspects) and the model itself can be seen as the 'internal' process.

To elucidate this process model further, a case from the next section can also be used here. Within the context of well-being, it has been documented that Latina women suffer the highest rates of cervical cancer of any main racial or ethnic group in the United States. This is exacerbated by the statistic that many do not attend their annual Pap tests examinations. This highlights a lack of participation that, when compared to other ethnic groups, clearly indicates a social disparity. By using the process model in Figure 1, certain questions arise – why in particular Latina women (position) and what social obstacles prevent a fuller participation (barriers)? These are the questions that a social designer investigates to separate out the design foci, and which will be discussed in the following examples.

## 4 Social Relations Design

It has been suggested that uneven social relations are the result of the process of contextual inequality, but it can also be argued that they are the engine of the process as well, contributing to inequality traps. A social relations design approach therefore focuses on social relations to effectively disrupt the process and can position itself to operate at the local scale, using community knowledge and networks to achieve a social interaction that is specific and collaborative. As contextual space also significantly influences the nature of the relationships, this 'externality' similarly requires attention. Contextual space challenges design, and challenges generate innovation.

This section draws from the previous discussion on the process of inequality to highlight some of the disadvantages that might be focused upon and introduces some successful examples of social design where this is already taking place. These disadvantages include access to quality health services, vulnerable living conditions in isolated or polluted environments, or cultural obstacles for full community engagement. Although these examples do not explicitly have a social relations focus, the comparable elements of the projects demonstrate the potential for the approach.

### 4.1 Access to Essential and Quality Health Services

**VisionSpring.** On their website ([www.visionspring.org](http://www.visionspring.org)) VisionSpring proclaims that 703 million people could have their vision restored with a pair of glasses, and 90% of those living with uncorrected vision live in the developing world. It is proposed that this situation results in an annual loss of US \$202 billion to the global economy. Subsequently VisionSpring supplies affordable glasses to regions within the developing world, targeting communities that have limited access to eye care. The company organizes 'vision campaigns', which usually take place at a school, church, or community center over the course of a day, and includes a temporary exam room and a pop up shop that sells glasses and protective sunglasses. These campaigns are operated by local, trained people, who educate communities about the importance of eye care and the benefits of corrected vision. These 'vision entrepreneurs' are often women, disrupting and eliminating context-specific barriers to an equal gender social participation.

If, as VisionSpring suggests on the website, glasses can increase productivity by 35%, then there is the potential to increase individual monthly income by 20%. Based on their conservative estimates for the average daily income of their customers, it is calculated that the annual increase in earning potential for each pair of glasses sold (multiplied by the two-year lifespan of a pair of glasses) has already resulted in an economic impact of US \$269 million. The website continues to suggest that recent research conducted in China determined that correcting vision in primary school students is the equivalent of an additional four to six months of schooling. The community outcomes of these operations are significant: not only do they allow workers and students alike to participate more fully in the world around them, but the uneven social relations (rural vs. urban or socio-economic access to quality resources) are also improved.

An integral component of this approach is a pricing strategy that addresses the need for glasses while creating viable businesses at the same time. VisionSpring sells frame options ranging from basic and affordable, to higher priced styles for those who can afford them. The income generated through the sale of these higher margin products enables the resource-intensive operations required to reach more remote locations with limited access to eye care.

This is a good example of social design using the process model presented in Figure 1. Within the context of well-being, it established the spatial and economic position of the disadvantaged communities, identified the barriers of integration (gender and lack of knowledge) and consequently facilitated participation. By operating at simultaneous scales, the project looked at the external context (what product was unavailable) and at the scale of social relations, which were preventing certain groups from fully participating.

#### ***Es Tiempo.***

*"Hispanic women have the highest incidence and mortality rates for cervical cancer of any major racial or ethnic group in the United States. While case studies show that the best way to prevent and detect cervical cancer is with annual Pap tests, many Hispanic women do not go to the gynaecologist regularly." [Alterkruse, 2010, cited in Shea, 2012, 90]*

Students from the Art Centre College of Design's Designmatters department used this context to design a campaign focused on the Los Angeles Latina community concerning the importance of annual Pap tests. The approach was place-based and participatory, working with the local community in focus groups to uncover the attitudinal and logistical barriers to regular check-ups. They had predicted that it would concern a lack of education regarding Pap tests but in fact it emerged that it was more about understanding the importance of an annual check-up. The research also showed that the group did not want to feel targeted and so the approach avoided being too direct, using personal language and familiar imagery (for example, on bus shelter maps and on the paper that covers the beds in the clinic examination room.) Shea [2012, 83] suggests this level of empathy is vital:

*"Instead of focusing only on a community's shortcomings, chart both its strengths (local language, style, skills) and challenges (literacy levels, drug and crime problems) and use that list as a guide through the project. Take inspirations from your interactions with community members and find ways to create an emotional tie with the general public by representing them with dignity."*

The campaign realised the need to build trust between the women and the doctors and so focused on the positive aspects of prevention rather than the negative consequences of inattention. This included creating a relationship with VISA card to help the women cover the time they needed to be absent from work to go to the doctor, and clinic kits to make the exam experience less distressing, which included a blanket, gown stickers and slippers. Ultimately the Es Tiempo campaign targeted the economic, gender and cultural barriers that created uneven integration, resulting in a greater access to vital health resources.

#### **4.2 Access to a Safe and Healthy Environment**

**Aqueduct.** The World Health Organization's 2013 annual compilation of health-related data noted that, despite increased global usage of improved drinking sources since 2010, progress has been irregular in different regions. One in eight people still do not have access to clean drinking water. This equates to almost a billion people, of which 37% live in Sub-Saharan Africa (WHO, 2010). Water-related diseases kill thousands of people

each day. Additionally, water sources in some remote areas can be a significant distance from habitation, requiring women or children to walk carrying heavy water vessels every day.

To contend with this major issue IDEO designed a tool to secure clean drinking water. The Aqueduct is a pedal-powered vehicle that transports, filters, and stores water, and addresses the two principal water challenges in the developing world: cleanliness and transportation. "The Aqueduct is designed to enable a person to sanitize and transport water simultaneously, potentially lessening the physical strain of the task and freeing up more time for work, education, or family." As the bike is pedaled, a pump attached draws water from a holding tank, and passes it through a filter, to a smaller, clean tank. It can filter while the bike is in motion or when stationary. The clean tank is suitable for home storage and use.

Presently it is not a viable solution due to production costs and resilience, but it does raise awareness around the water issues in developing countries and, as such, demonstrates how social relations can be improved by giving access to basic needs. The women and children who have to walk considerable distances to get the water could potentially be able to gain paid employment or attend school as a result of this invention, allowing them an equality of opportunity with others who have easier access to water sources.

This project focused on an issue that involved a similar 'position' across many communities, that being a location with inadequate access to potable water. The barrier of insufficient resources is still being worked through to create the opportunity of full participation of individuals in society, be it in children being able to attend more school or through improved community health.

#### **4.3 Access to Full Community Engagement**

**projectOPEN.** This project from the University of California Los Angeles (UCLA) focused on the issue of homelessness in Santa Monica, California, seeking to empower the homeless community by removing the barriers it faced to accessing important knowledge and amenities. The research group considered the various causes of homelessness and met with over forty associated organizations. The aim was to set up a robust

network among these organizations and facilitate better communication between them, while ensuring that the homeless people were fully educated on their rights and what resources were available to them.

The outcome was a services resource guide called project OPEN that opened out into a large map that identified valuable services, such as doctors' offices, shelters, social services and food banks with information such as opening hours, contact info etc. On the back of the poster there was a reference to legal rights and safety tips. What is particularly interesting about this example is that the Santa Monica's city government withdrew their offer to pay for and distribute the map when they discovered that the legal rights were printed on the back of the resource. It was they feared that this would increase levels of homelessness. Ultimately the map was distributed through a different printer. "This points to the importance of keeping the design process transparent, meeting with the community, clients, and funders frequently to keep everyone on the same page." [Shea, 2012, 67] It is also a display of how uneven social relations can prevent access to knowledge that can remove barriers to full participation.

The success of the initiative has seen it expand to include other cities, including the development of making a tri-lingual map in English, Spanish and Chinese. This is a good example of how social relations design can operate over time, building on an initial venture to develop into a larger project with a greater impact potential. It is useful when discussing scale to consider time and the sustainability of projects. Social relations design should not focus solely on one-off projects but aim for long-term commitments, which this project has the opportunity to achieve. Overall, this project demonstrates how the process model in Figure 1 can assist social designers in identifying the key mechanisms in a situation of inequality. It clearly shows how the barriers of prejudice and power were able maintain the disadvantaged position of the homeless community, preventing full participation.

## 5 Conclusions

The notion of social design is both vibrant and complex. It is characterized by a 'no fear of failure' type of exploration and disruption, thorough observation and

preparation, and a participatory, empathetic approach to co-creation. It is place-based and is committed to sustainability and positive change. This paper has made no notable attempt to define the concept but has rather suggested that a new social design focus might be capable of producing even more positive, effective and efficient social outcomes. This new focus has been called social relations design and seeks to disrupt the process of inequality by focusing on uneven social relations in various contexts. The process of inequality, as understood through a conceptual process model, operates within a 'complex whole' of externalities and internal relations and consequently requires a design strategy that can work at different scales simultaneously. It has been argued here that a social relations design is capable of taking on this challenge and therefore causing significant disruption to on-going disparity traps and processes.

The examples used, loosely categorized into access to services, environment and engagement, illustrate the potential for an approach that is place-based and focused on the specific relations and issues of a context. Individuals and groups in communities, and communities themselves, often struggle in a network of uneven, dependent social relations and design thinking has significant potential to remove one or two of these barriers to create greater participation and equality of opportunity.

The main challenges for social designers interested in this focus are working with a community to isolate particular uneven social relations within a context and doing this in such a way that is non-invasive or directional. This requires considerable preparation and observation to 'map' a matrix of social relations in the community before discussing which of the relationships can be considered dependent or uneven, and therefore contributing to inequality. Once the community – or community group – has identified specific social relations, then the design space has been created and is ready for the initial stages of a co-design project. It is vital that the design space has been selected by the community. This methodology, although not fully developed in the article, is recognized here as having significant potential for further discussion within a social relations design context.

The issue of scale has been raised in this article, notably regarding the simultaneous operation of external and internal influences. However, it was also briefly suggested that a temporal scale also needs to be considered. This refers to the need for a sustained and sustainable commitment to the project. Inequality, as discussed, is complex and persistent and it requires a concerted effort to disrupt its processes. Design is capable of doing this but not through one-off, 'band-aid' projects. Social relations design needs to be proactive, flexible and committed as communities are dynamic entities, vulnerable to external pressures. And more than anything a social relation focus approach needs to be unshakably contextual and designed to scale.

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# Social Connectedness and Inclusion by Digital Augmentation in Public Spaces

## Abstract

With several design iterations we explored the ways of increasing people's feeling of inclusion and connectedness in a public space using interactive public art installations as media. The study used the Social Connectedness Revised Scale and the pictorial Inclusion of Community in Self as measurement tools and a university cafeteria as the context. Experiments were carried out to investigate the possible difference among several types of interaction elements, examining the influence on people's perceived sense of inclusion and connectedness to others who were present in the same space. Subsequent interviews were conducted to support the findings of the questionnaires and to shed light on some of the results. The results showed a notable difference when the physical space was augmented with interactive digital content.

## Keywords

Social connectedness, social inclusion, public spaces, interactive public arts

## 1 Introduction

Cities are evolving at a rapid pace. A problem of this rapid evolution is that people may feel less and less connected to their city as they may find it challenging to keep up with all the changes. In public spaces people usually do not spend much time. A way to

engage people in interacting more with their city is through public art installations where onlookers change their participative roles from spectator to actor by influencing the art piece in their own way [1-4]. Improving quality of life are issues that many growing cities must deal with. People want a better quality of life. To increase the quality, cities are turning in part to strategies to heighten the sense of inclusion and connectedness of their citizens. Making spaces inclusive instead of exclusive is a trend that is growing worldwide, particularly in city planning for newly evolving Chinese cities [5, 6]. The design context for the concept is public spaces across a city. On these locations a network of the installation "Leave your mark" would be placed to allow people to freely express themselves on a blackboard. This would enable them to augment the public space in which they find themselves with a digital added element connecting several locations of the city together. This approach is to help people feel more connected with and included in the space they are in.

We started the project by asking ourselves the question "how to design a public digital art installation with digital augmentation to physical spaces to increase people's feeling of inclusion and connectedness?" To answer this question, taking into account our initial concept of leaving their marks, the first step was to determine whether, if people were given tools in the form of markers and papers in a public space, they would use them. If this

was not the case, the whole project could be stopped at that stage. From this question we derived a hypothesis:  
 H1: When giving people a designated place to express themselves with tools to do so (pen and paper for example), they will not do so.

If H1 can be rejected, we could take the concept further. Buildings in a public space consist of a mix of geometric shapes. When creating an interactive public art installation system, geometric shapes are thus truly important and should be taken into account to fit the surroundings. A few more hypotheses were then derived:  
 H2: People will not use the geometric shapes for their forms of expression.  
 H3: People will not use the geometric shapes for their forms of expression when hints to this option are given.  
 H4: Even when giving people hints to the possibility of using geometric shapes, their sense of connectedness is not different from when only using a plain blackboard with nothing added.

We introduced a blackboard in later experiments for people to leave their marks. A blackboard is a medium that has a low threshold, and that everyone knows how to interact with. The blackboard was thus made to explore if such types of expressions do, or do not, influence people's feelings of inclusion

and connectedness. The digital element that will be discussed later in this paper is an addition to this exploration. To study people's sense of connectedness and inclusion with the blackboard, four more hypotheses were proposed:

H5: People's sense of connectedness to the space – and to others in the same space – will not be increased by letting them express themselves in a designed way with the blackboard in the public space.

H6: Projecting a feed from one blackboard on another, allowing people to see other's drawing, etc. will not influence their sense of connectedness.

H7: Letting people express themselves in a controlled manner with the designed blackboard in the public space will not influence people's sense of inclusion.

H8: Projecting a feed from one blackboard to another, allowing people to see others' drawing will have no influence on their feeling of inclusion.

We will first introduce some related existing concepts and will then describe the proposed concept. This will be followed by the initial explorations conducted in line with the above mentioned research question and hypotheses. The tools used will subsequently be explained, followed by an explanation of the final experiment, including the setup, participants and procedure. The results will then be presented and discussed and analyzed with conclusions.

## 2 Related work

Many people have seen graffiti put on a wall or building or even very elaborate chalk drawings on the ground of a public space in their city. People expressing themselves in creative ways in the public space can thus be seen as an event that has some history. But next to these unorganized, often illegal forms of expressions there are also designs or organized events that give individuals in the space the chance to express their individuality and share their thoughts with their community. Flash mobs are such an example.

"Infecting the city" is a small festival in Cape Town, South Africa (Fig. 1(a)). Initiated by the Africa Centre, the festivals' goal is an endeavor to kindle the interconnectedness of the people in the city through artistic expressions, as they say "making the public space public" [7].



Fig. 1. (a) a public art installation in Cape Town, South Africa [7]; (b) the Obliteration room [8]; (c) Community Chalkboard [9]; (d) Before I Die [10]

Japanese artist Yayoi Kusama created the Obliteration room (Fig. 1(b)). Her white living room is personalized by every visitor to the space who is provided with a colored sticker dot that they can choose to put wherever they wish in the space. This means that every dot is the expression of the visitors experience in that space [8].

Community Chalkboards created by the Company Site works in Charlottesville Virginia (Fig. 1(c)), in the United States consists of a public chalkboard. It represents a memorial for the first amendment where anyone can share their thoughts and opinions [9].

Candy Chang started the “Before I Die” project after losing a loved one (Fig. 1(d)). Before I Die started in New Orleans. It is a chalk board with a grid created with the start of the sentence “Before I Die...” with room for people to fill in the rest of the sentence. Anyone who walks past this chalkboard can pick up a piece of chalk and write down what they want to do before dying. The inspiring project has since expanded to 189 other cities across the globe [10].

Research that studies the effects of intrinsic and extrinsic motivation, in some cases is closely related to the topic at hand [11, 12]. Research conducted in the field of inclusion and connectedness has mostly been conducted on a purely digital or purely physical field. Such research used tools like blogs and mobile phones for the concepts. An example is the work by Shuk Ying Ho who studied the effects of location personalization on individuals’ intention to use mobile services [13].

This research differentiates itself by combining the digital and the physical while using tools for measuring inclusion and connectedness for public art installations in a public space. Next the concept “Leave your mark” is briefly described

### 3 “Leave your mark”

People were provided with an opportunity to interact in a playful way by “drawing” and leaving their mark behind on the public space (Fig. 2). The opportunity gave them a chance to express themselves by playfully triggering and intrinsically motivating them. The concept involves projection mapping and the use of digitally augmented



Fig. 2. “Blackboard” concept

blackboards to create a public art growing system in a city. The goal of the concept is to increase feelings of inclusion and connectedness of the citizens of the city to each other and to the public space they are in.

#### **Aspect 1:**

Imagine, a blackboard situated on a building in a city. A person walks by, grabs a piece of chalk and starts drawing or writing on it, leaving their mark. The blackboard projects the drawing or written words of those who left their mark onto the building, in other words augmenting the physical world in a digital way.

#### **Aspect 2:**

A more connected aspect was also added to the concept. In some locations the blackboard will be provided with a camera. The feed of this camera will be projected onto a blackboard in another location in the city. If a person walks by this secondary location, they could possibly see someone, a complete stranger, leaving his or her mark on that first blackboard. All of this is carried out using video feed. This creates the result that people see individuals in another location walking by – or sharing on the blackboard of this other location – where the first individual is not actually him or herself.



(a)



(b)

Fig. 3. Exploration results

## 4 Explorations

### 4.1 Exploration 1

The first step into the development of the concept was to see if people would be triggered to share

	Positive	Neutral	Negative	Total
Drawing	27.2%	31.6%	2.6%	61.4%
Text	18.4%	13.2%	7.0%	38.6%
Total	45.6%	44.8%	9.6%	100%

Table 1. Percentage of elements shared

something in a public space or not (H1). An initial exploration was carried out for this purpose. Eight pieces of A0 papers were hung in various spaces at Eindhoven University of Technology (Fig. 3 (a)). Each large paper had 1 or 2 colored markers attached alongside the papers.

As a trigger, each paper also had the words: "Leave your mark, draw, write, do whatever you like". They were left hanging for 1 week on average.

In total 144 things were shared (Table 1). Seventy of these were drawings and 44 were texts. We could speculate from this that people are more inclined to draw than write. This meant that the final concept should be open to both possibilities. 37 of these (32.5%) were on the papers put in the auditorium close to the cafeteria of the auditorium in the university. Partially due to this result, this location would later be chosen for the subsequent tests as it was the most elaborated paper. Daily visits to each location showed that once the high threshold of the first drawing or two was shared, the threshold seemed to be lowered as more people shared in a shorter time span. This indicated that, given time, people would be triggered to participate through the participation of others.

The first paper and pen based exploration showed that people appeared to be triggered by the presence of paper and pens to draw or write something on the sheets of paper hung around campus. Public spaces are constrained by the shapes and forms of the buildings in that space. This was seen as an interesting opportunity to use the final concept to augment the physical space. But if constraints are given, such as paper with cut out shapes, would individuals use them?

### 4.2 Exploration 2

The same format was used as for the first exploration.

	Using the cut out shape itself				Using the inside of the cut out shape			
	Positive	Neutral	Negative	Total	Positive	Neutral	Negative	Total
Drawing	22.9%	25.7%	0%	48.5%	15.8%	7.2%	0%	22.9%
Text	7.2%	7.2%	1.4%	15.8%	7.2%	5.7%	0%	12.9%
Total	30%	32.9%	1.4%	64.3%	22.8%	12.9%	0%	35.87%
	percent of total			64.3%	percent of total			35.7%
Combined total								70
Combined percentage								100%

Table 2. Elements shared using the outside of the shape or the inside of the shape

8 papers with pens were hung in the same 8 locations. The difference was that these papers had cut out geometric shapes in them (Fig. 3(b)). The idea behind the geometric shapes is that they are representative of the windows and doors of a building.

The total number of shared marks was 70 this time (20 texts and 50 drawings). The number of drawings that ended up using the inside of the cut out shapes was of 45 (35.7%). People's use of the cut out shapes was 25 (64.3%). See Table 2.

This allows for speculation that people can be triggered to use geometric shapes for the use of their drawings and shared content. Though because of the nature of the prototype used in the final experiment, however, individuals will not be able to draw in the holes.

## 5 Experiment

The cafeteria of the auditorium at the Eindhoven University of Technology was chosen as the location for the experiment. It was the location with the most results during the pen and paper exploration. It is a social interaction location that resembles the squares in cities with restaurants and cafes in interaction, attitude and frame of mind.

Depending on courses and days of the week, it is uncommon for the same group of people to pass through the cafeteria of the auditorium every day. Enough participants and the same profile of them allowed for both between group tests that has less learning effect.

The tests were conducted over lunch hours, between 11.30 AM and 1.45PM on Tuesdays and Fridays. Depending on the tests, the tools used were the paper questionnaires (SCS-R, ICS), the handmade blackboards and chalk (Fig. 1(a)); a projector and a pre-filmed movie of people drawings on the blackboard on a computer (Fig. 4(b)).

### 5.1 Instruments

#### Social Connectedness Scale Revised

The Social Connectedness Scale Revised (SCS-R) scale [14] was used. This 20-declaration scale asks people to grade from 1 to 6 depending on whether they



Fig. 4a + 4b. Experiment settings

respectively strongly agree or strongly disagree with the statement made. High internal reliability of the scale at a degree of  $\alpha=0.86-0.89$  across the scale gives us enough confidence in using this scale in the experiment.

#### Inclusion of Community in Self scale

The pictorial Inclusion of Community in Self (ICS) scale [15] was also used in the experiment. The scale is composed of 6 pictorial representations of two circles (one representing community and the other representing the "self"). Each of the pictorial representations varies from its neighbor by increasing the intersection surface. An increase in this intersection shows a closer sense of inclusion to the city and people in their environment.

#### Interviews

Interviews were conducted on dates and times that were suitable for the interviewees. Interviewees were either interviewed at their workspace or in the auditorium cafeteria depending on what was more suitable for the interviewees. Interviews lasted an average of thirty minutes and varied from fifteen to forty-five minutes. Ten people in total were interviewed, two from each test. The purpose of the interviews was to gather

valuable, qualitative information that might go unsaid through the self-examinations tests conducted first.

### 5.2 Participants

100 students participated in the experiment (20 participants for each test). They were from varied ethnic backgrounds and level of education accomplished at the time of the test (Bachelors students, Masters Students, PhD students) and varied in age between 18 and 33. The average age was 22.31. Of the 100 participants, 61 were men and 39 were women.

### 5.3 Procedure

After each test, they were personally asked to fill in the questionnaire that included the above-mentioned scales. Participants were informed about the purpose of the form. The form requested participants to fill in their personal email address if they agreed to be contacted for further interviewing. No reward of any kind was provided to the test participants.

For every test group, two people would be selected for interviews in order to gather qualitatively useful data, one with a higher score on the Social Connectedness Revised scale and one with a lower personal score.

### 5.4 Data analysis

The results from the scales used in the control tests, test A, B and C (to be described in detail later in this section) were evaluated according to their described methodologies, calculating both scale and item mediums as well as the standard deviations for each. To determine whether the difference in means is statistically significant, a one tailed ANOVA test was conducted. The analysis is a one-way because there are more than 3 groups (tests) with participants that are in no way related to each other aside from visiting the same location. Bonferroni is chosen for these reasons as the post-hoc settings for the one-way ANOVA test. Bonferroni' test is also suitable when small numbers of pairwise comparisons are being analyzed.

### 5.5 Test settings and conditions

#### *Two control tests*

Two control tests were conducted. These control tests were carried out in order to have a valid baseline with respect to the level of inclusion and connectedness within the campus in the cafeteria of the auditorium during lunchtime. This allowed for a comparable control

context for the results of the follow up data. The control tests were conducted on Tuesday May 14th 2013 and Friday May 18th 2013. The 20 participating people were asked to only fill in the same questionnaire that included the SCR-scale and the ICS-scale.

#### *Test A*

Test A was conducted on May 22th 2013. Two blackboards were placed on opposite sides of the vending machine close to the tunnel leading to the main building of the cafeteria of the auditorium (Fig. 5).



Fig. 5. Test A setting

Both blackboards were identical and were provided with colored chalk. The words "Leave your mark" were printed and hung above the blackboards. People who chose to come and share something were asked to fill in the same questionnaire that the individuals in the control test had filled in. Because most participants ended up only seeing and experiencing one of the two blackboards, the second one was found to be excessive for subsequent tests.



Fig. 6. Test B setting

### Test B

Test B setting is similar to Test A, but with an added digital aspect. It was conducted on Tuesday the 28th of May 2013. A previously filmed 2-hour footage of people occasionally coming to draw something was projected on the board (Fig. 6). People who chose to come and share something were asked to fill in the same questionnaire that the individuals in the control test and test A filled in.



Fig. 7. Test C setting

### Test C

The final test was carried out on Friday the 31st of May 2013. Similar to test B, a projector was used once more in this setting. In this test, however, hints to the use of the geometric shapes were projected. That is, how people could use the shapes to incorporate them into their drawings instead of drawing around them (Fig. 7).

This test would show whether or not it would be necessary, or even useful, to have this constraint of geometric shapes based on the public space in the real life version of the concept. As already stated the geometric shapes are representative of windows and doors of a building. This final test was thus to re-tune the concept and to see if people would use these shapes or not.



Fig. 8. (a) Using the shape as basis; (b) Using the shape as inspiration

## 5.6 Results

### Observations about the use of the geometric shapes

In test A, 2 people used the geometric shapes as basis or inspiration for their drawings. In test B, 6 people used the geometric shapes as basis or inspiration for their drawings. In test C, 15 people used the geometric shapes as basis or inspiration for their drawings. Examples are shown in Fig. 8.

### Social Connectedness Scale Revised

There was no statistical significance between the two control tests. This shows the reliability of the scale used in the context. Consequently, the results of the two control tests were merged into one.

The mean result for the control test was 54.90 with a standard deviation of 7.78 and a standard error of 1.23. This compared to the total mean of test A that was of 60.40 with a standard deviation of 6.35 and a standard error of 1.42. The mean result for the test B on the SCR scale was 68.75. The standard deviation is 6.53. There is a standard error of 1.46. Test C had an average of 60.75 with a standard deviation of 7.29 and an error margin of 1.63.

		Mean Difference	Std. Error	Sig.
MULTI_SCORE	control test	-5,50000 <sup>*</sup>	1,90689	,037
	test B	-13,85000 <sup>*</sup>	1,90689	,000
	test C	-8,85000 <sup>*</sup>	1,90689	,022
test A	control test	5,50000 <sup>*</sup>	1,90689	,037
	test B	-8,35000 <sup>*</sup>	2,27117	,002
	test C	-,35000	2,27117	1,000
test B	control test	13,85000 <sup>*</sup>	1,90689	,000
	test A	8,35000 <sup>*</sup>	2,27117	,002
	test C	8,80000 <sup>*</sup>	2,27117	,004
test C	control test	1,85000	1,90689	,322
	test A	-,35000	2,27117	1,000

Table 3. Bonferroni SPSS results of the SCS-R scale across the tests

The statistical significant variances between the control tests, test A, B and C (Table 3) show a significant improvement in SCS-R scores ( $p=0.037$ ,  $0.000$ ,  $0.022$  respectively). The result also shows significant increase in SCS-R scores of B over A ( $p = 0.002$ ) and B over C ( $p=0.002$ ). There is no significant difference found between A and C.

### Inclusion of Community in Self scale

The data of the control test was a mean of 3.90 with a standard deviation of 0.84 and a standard error margin of 0.13. Test A had a mean of 4.50 with a standard deviation of 0.60 and a standard error margin of 0.14. For test B, the mean was of 4.85 with a standard

i/j test condition		Mean Difference (i - j)	Std. Error	Sig.	95% Lower Bound
control test	test A	-.80000	.20930	.031	-1.2640
	test B	-.95000	.20930	.000	-1.5140
	test C	-.60000	.20930	.019	-1.2140
test A	control test	.80000	.20930	.031	.0360
	test B	-.35000	.24174	.908	-1.0013
	test C	-.35000	.24174	1.000	-.7013
test B	control test	.95000	.20930	.000	.3860
	test A	.35000	.24174	.908	-.3013
	test C	.30000	.24174	1.000	-.3513
test C	control test	.60000	.20930	.019	.0860
	test A	.55000	.24174	1.000	-.8013
	test B	-.30000	.24174	1.000	-.9513

Table 4. Bonferroni SPSS results of the ICS scale across the tests deviation of 0.67 and a standard error margin of 0.15. Test C had an average of 4.55 with a standard deviation of 0.83 and a standard Error of 0.18.

Based on the one-way ANOVA calculation conducted through SPSS the statistical significance of this variation in mean between the control tests and the other tests (A, B and C) was significant ( $p=0.031, 0.000, 0.015$  respectively).

When looking at the scores in the ICS scale of B over A, B over C, and A over C, there was no significant difference found.

## 6 Discussion

The study presented is exploratory and aimed at answering the research question which emerged during the early project phase. The research question was decomposed into smaller ones with which the hypotheses were set.

The tests were conducted in a more controlled manner in a smaller environment than the city that the concept is aimed at. It should be stated that the validity of the tests is limited by the experimental environment. The following discussions are based on the assumption that the results concluded from these experiments would be also valid for the city environment.

### 6.1 Use of geometric shapes

*H2: People will not use the geometric shapes for their forms of expression.*

The results of both the second experiment and of the final experiment show that when there was no real hint to use the geometric shapes a few individuals did use them as basis or inspiration for their drawings. Based on only these observations, hypothesis 2 cannot be fully

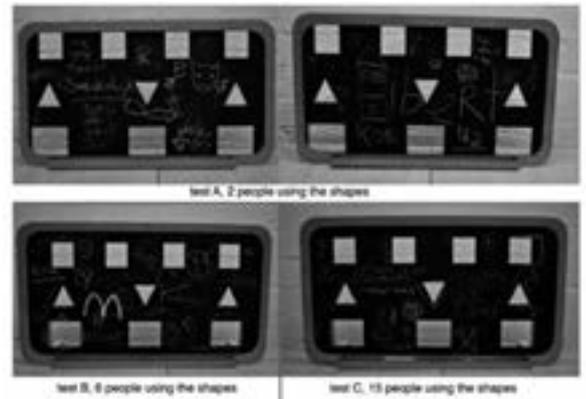


Fig. 9. Number of people using the shapes for their drawings per test

rejected. This is because, without hints, even though people used the shapes, only very few people did so.

*H3: People will not use the geometric shapes for their forms of expression when hints to this option are given.*

For test C, there was a hint projected on the blackboards for people. In this case more individuals used the geometric shapes as inspiration or for part of their drawings in test C than when compared to tests A and B. In the case of test B more than double the number of people did so and, when compared to test A (Fig. 9).

Observing the statistical analysis based on SCS-R and ICS when comparing test C to A and B, one may conclude that providing hints on drawing along the geometric shapes does not contribute to the participants' feeling of social connectedness and inclusion. In Fig. 9, however, it is also evident that the participants did follow the hints and geometric shapes that were taken into account by others when interacting with the blackboard.

When looking at the proportions, it can be inferred that H3 is negated as more people did end up using these shapes. Based on these conditions, it can be stated that there is a relevance to keeping the use of the geometric shapes in the final version of the concept.

*H4: Even when giving people hints to the possibility of using geometric shapes, their sense of connectedness is not different from when only using a plain blackboard with nothing added.*

Based on the results of test A over C for the SCS-R scale, it can be supposed that adding the hint only adds

to people using the geometric shapes as stated earlier in this discussion but not the feeling of connectedness. In other words, it appears that the individuals in test C and A share a similar sense of connectedness and inclusion. This can mean that H4 can be accepted.

## 6.2 SCS-R scale

When comparing the mean of the tests, it appears that there is a strong sense of connectedness increase when comparing the control test to the other tests.

The results show a significant statistical difference between the control test and test A. This could mean that people had a higher sense of connectedness in the space with other people in the same space because of the presence of the blackboard and their interaction with it. The similar significant difference is also found when comparing Test B and Test C to the control test.

As the Hawthorne effect [16] suggests, any interference or change to an environment of the participant that gets their common attention will have an impact on their feeling of connectedness. We have to agree that it is not entirely clear whether it was the design of the blackboard that made a difference. Test A, however, shows that a difference can be made; moreover it is used as a reference for test B and C in which we pay more attention to digital augmentation. We may also have the similar discussions when comparing Test B and C to the control test.

*H5: People's sense of connectedness to the space - and to others in the same space - will not be increased by letting them express themselves in a designed way with the blackboard in the public space.*

The results from the various tests SCS-R numbers contradict H5. It can be interpreted to mean that the H5 is voided by these results, seemingly showing that there is an increase in the feeling of connectedness of people when letting them express themselves in a public space. This finding led the researcher to ponder whether there are differences in the results that are significant between test A, B and C.

Between A and B: B appears to have a significant difference over A. Interacting with other people in real time with digital augmentation seems to have a strong impact on social connectedness.

Between B and C: The significant difference for B over C shows that interacting with other people in real time with digital augmentation has a stronger effect than when digital augmentation is only about the hints regarding geometric shapes.

*H6: Projecting a feed from one blackboard on another, allowing people to see other's drawing, etc. will not influence their sense of connectedness.*

When comparing B to A and B to C, the results allow speculation that H6 can be rejected. The influence of the added digital feed seems to have had a very big influence on people's feeling of connectedness. This result also confirms the result from other studies [3]. This aspect was further explored more closely in the interviews.

The results show that there is no significant difference between A and C. It would seem that the digital augmentation does not have an influence on the feeling of social connectedness. This suggests that, in these cases, the physical interaction with the environment can be replaced with well-designed digital interaction, without harming the participants' feeling of social connectedness.

One could suggest that this lack of difference between tests A to C as opposed to the presence of the difference between the control test and the other tests is due to the Hawthorne effect [16]. This aspect would need to be examined more closely in a future experiment.

## 6.3 ICS scale

*H7: Letting people express themselves in a controlled manner with the designed blackboard in the public space will not influence people's sense of inclusion.*

When comparing test A, B and C to the results of the control test, the participants in these tests appear to have felt more included in the community than those in the control tests. This means that H7 can be, statistically speaking, disproven. It can thus be postulated that through the act of participating in the test in any way, even just by leaving their mark, people felt an increase in their sense of inclusion in the community.

*H8: Projecting a feed from one blackboard to another, allowing people to see others' drawing will have no influence on their feeling of inclusion.*

When comparing the results of test A to those of test B, the difference is not significant. The same applies for the results of test A and C. Furthermore, this equally applies for the comparison of test B and C. This shows that H8 was not rejected.

Due to the difference present in the SCS-R scale but lacking in the results of ICS scale, it could be suspected that the sensibility and validity of the ICS scale could be brought into question as a tool set for such tests.

#### 6.4 Interviews

When asked to describe a moment where they felt particularly included, 9 out of the 10 people interviewed described stories where they got to know strangers due to either unexpected events (for example in the Netherlands, something going wrong with a train) or due to the setting (for instance a festival). From this information it would appear that the event of connecting to people one did not know beforehand really influences their feelings of inclusion.

In the cases where someone else had expanded the drawing of the interviewee, responses were strong and similar. As one person said, "I like it! I like the shape! It means, I feel like I made something for someone. I wanted to keep going, I was being helpful to someone else." People felt they helped each other and like they became part of the systems by collaborating.

When people saw others draw, both in real and with projected ones, the responses were as follows: "In a way we were making something together. If they were drawing on the same board at the same time it influenced me more. We were doing it together and not by myself. I felt like we were drawing together." "When I drew I saw cat whiskers already drawn on the board. They were inviting and felt open to me. I also saw a smiley... I felt open and happy, the drawings made me laugh. I drew something and it was funny because suddenly a persona appeared on the beamer and started drawing something similar to my drawing. That made me feel happy." The existing drawing influenced people by apparently lowering the threshold and inviting others to participate. They stated that they felt happy when seeing others draw.

When asked how they felt seeing their drawing having become part of a system the response of the 6 non-

control group interviewees were all similar as well: "As I said I felt like part of the blackboard system. I did not feel excluded. We seemed to really be working together to create something even though we did not know each other." This was a sentiment echoed by all.

Participants in the interviews from test A and C said that they felt more included when other people had extended their own drawings. The revisiting fact, or seeing the final results from the test, influenced how people felt afterwards. Here it can be asked whether seeing one's work elaborated on during the next visit to the public space influences the feeling of inclusion. It could also be interesting to explore whether the beamed feed of other people drawing – or if the extensions of a drawing by others – is influential on people feelings of inclusion.

Intrinsic motivations are founded in our innate human nature. Our ingrained features push humans to be driven by curiosity and to participate in social activities [12]. It became apparent through the participants' reactions in the interviews that they were triggered by their curiosity and their natural intrinsic motivation to participate in this social activity. One individual, for example, stated, "I was thinking of what everyone else put on the blackboard. (What they wrote or drew). I looked at how what I left would compare to what others put. It influenced the colors and size and location I chose. But it didn't influence what I drew. I liked it."

#### 7 Conclusions

The beauty of the concept "Leave your mark" lies in its simplicity and the ease for people to step in and out creating a reasonably low threshold. It seems to be an appropriate solution to design a public art installation with digital augmentation to the physical world to increase people feeling of inclusion and connectedness.

In this specific case we can speculate from the answers that the presence of a prototype of the concept influenced people's sense of connectedness and inclusion. The lack of difference found between tests A, B and C in the ICS scale is unlikely to be caused by the Hawthorne effect. This is a point that should be explored further. Specifically as it related to the results of the Inclusion of Community in Self scale where no

significant differences were found between the tests. Seeing there was such a significant difference in the SCS\_R scale, which was lacking in the ICS scale, this could bring into question the validity and effectiveness of the ICS scale or it is simply because the social connectedness and inclusion are not coupled concepts.

The results of the Social Connectedness Revised scale however were more noticeable. Using the designed concept "Leave your mark" as a form of public art system could help citizens of that city feel more connected. It can be concluded that when there was the added digital feed of other people drawings, people felt a much higher sense of connectedness. This was also confirmed by the results of the interviews.

Given that this was an exploratory test conducted in controlled settings away from the real world set up, there are limitations with regard to the results. It is important to note that this test should be conducted again with a real setup in a public space. This is necessary to determine if the results will coincide with those found here. This exploratory research project could be seen as an interesting start to inspire future work and explorations in public digital art installations with digital augmentation to public spaces in cities.

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# Multi-tasking and Arduino: Why and How?

## Abstract

In this article I argue that it is important to develop experiential prototypes which have multi-tasking capabilities. At the same time I show that for embedded prototype software based on the popular Arduino platform this is not too difficult. The approach is explained and illustrated using technical examples – practical and hands-on, down to the code level. At the same time a few helpful notations for designing and documenting the software are introduced and illustrated by the same examples. Finally a few case studies of the technical approach are listed.

## Keywords

Prototyping, specification languages, parallelism, multitasking, experiential, models

## 1 Introduction

In the world, in which we live, there is a lot of parallelism. Around us many things happen and they happen more or less simultaneously. Zooming in to the detailed behavior and the internal working of the objects around us we see more parallelism. If we zoom out to our environment and consider what happens at some distance even more parallelism becomes visible. As human beings, we cope with this aspect of the world's complexity remarkably well. We are able to perform multitasking (Fig. 1).



Fig. 1. Humans are good in multitasking: seeing, navigating, communicating, feeling temperature etc.

So if we are designing artifacts which display some form of intelligence, it is natural to assume that they can perform multitasking as well. For ambient intelligent environments, this is usually the case indeed, which is no surprise when they are equipped with powerful sensors such as cameras and data from mobile devices; these are all connected to networks of servers which run in the background with lots of parallelism anyhow. Modern computers, including PCs, smart phones and Internet servers are equipped with Operating Systems which allow for many parallel processes on a single computer. Even small stand-alone embedded processors can have operating systems, usually marketed as RTOS (real time operating system). Technically these are appropriate, but somehow they are considered high-threshold for programming quick experiential prototypes. For this reason interaction designers and industrial designers

prefer systems such as MAX, Processing (for PC and MAC platforms) and Arduino (for embedded applications). Arduino does not come with an operating system. It works with the same theatre metaphor as the Processing environment which is meant for creative work on PC. There are two functions: `setup()` prepares the stage and `loop()` defines the actions.

Arduinos are used as control devices, in combination with sensors in of a huge variety of experimental art installations, experiential prototypes and experimental research vehicles. See [1] and [2]. Some of these systems sense light conditions, others detect sounds, temperature differences, bodily parameters, movements and so on. Their actuators include motors, loudspeakers, lamps, lasers, fluid valves and servo motors, voice coils, memory metals, just to name a few of many options.

For many of these sensors and actuators there is a software library and examples how to connect, read and write these sensors. Usually `setup()` defines which device is connected to which input or output pins. And usually `loop()` contains a few read, write, and delay actions. The actions depend on the inputs received so a few if-else or switch-case statements are thrown in and a few variables to keep track of what goes on in the external world.

All this is well, but when combining a few sensors and actuators the programs suddenly become much harder to design. During the delay needed for one task, the Arduino is unreceptive for the signals of other sensors. All the nested if-else and switch case statements soon blow up the `loop()` to a multi-page debugging nightmare. Lowering the project's ambition level and adjusting the planning to allow for more programming and debugging time are typical decisions I witnessed in student projects.

As a way out, some of the designers work with interrupts, allowing external events to launch interrupt service routines which briefly suspend the ongoing task. No doubt this is a powerful technique, but it requires a much deeper knowledge of the processor and its hardware. Often the service routines are written in assembly language and manipulate the processor's timer registers.

In this article I describe an approach to avoid these difficulties - the only price being a bit of discipline to adhere to an orderly structure. At the same time the approach offers very nice opportunities to document the software at a higher level than the code itself. In particular, I propose State Transition Diagrams (STD, sometimes called Finite State Machines) as a helpful way of explaining and documenting the logic of decision making (normally implicitly coded in if-else and switch case). And I propose Data Flow Diagrams (DFD) as a desirable way of giving a high-level overview of the parallel tasks going on and how they communicate via shared variables.

The notations of STD and DFD are not new: they were developed in software engineering and telecommunication industry more than two decades ago. They are among the simplest and yet most powerful notations of software engineering. Yet they appear not to have been handed down with the other nice things which were adopted in Arduino culture.

The next sections contain examples illustrating the proposed principles. The nice property of the approach is that it is compositional: the `loop()` does not become exponentially more complex. A `loop()` with two parallel tasks contains 2+1 statements. A `loop()` with twenty parallel tasks contains 20+1 statements.

## 2 State Transition Diagrams

The example of this section serves mainly to introduce the STD notation. The system is the type of light encountered in the corridors of hotels: the guest pushes a button and the light goes on. After ten seconds, the light goes off automatically. The system therefore has two states: ON and OFF, represented by the circles in the diagram of Fig. 2.

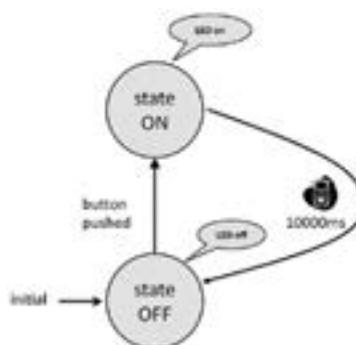


Fig. 2. State Transition Diagram with two states.

One of these states is labeled to be the initial state. The states themselves are an abstraction and the text balloons tell about the resulting actions in the real world. The transitions from one state to the next are represented by arrows. Each arrow is labeled by a condition or an external action which tells when the transition happens. The transition from state OFF to state ON happens when the hotel guest has pushed the button. The transition from state ON to state OFF happens when a timer set to 10,000ms goes off. Typical experiential prototypes cope with experiences ranging from a few milliseconds to many seconds or minutes, which is why time is specified in ms throughout this article.

The STD is a high-level description of the behavior which is helpful for communication and documentation purposes. The same behavior will be coded in a programming language, for example the C++ dialect of Arduino, but this tends to be harder for stakeholders who are not familiar with such language. This is the code:

```
void LEDstep()
  int button;
  button = digitalRead(buttonPin);
  switch (state){
  case OFF:
    if (button == HIGH){
      state = ON;
      timer = 1000; //10000ms
      analogWrite(ledPin,255);
    } break;
  case ON:
    if (timer <= 0){
      state = OFF;
      analogWrite(ledPin,0);
    } else timer--;
  }
}
```

This LEDstep can be viewed as a process which runs forever. When it writes 255 to the ledPin, the external light will be switched on (assuming LED light). The step is to be called every 10ms which guarantees that the timing works right. The rest of the code now follows the theatre metaphor.

```
void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(buttonPin, INPUT);
}

void loop() {
  LEDstep();
  delay(10);//ms
}
```

The state transition diagrams are not restricted to the on and off states, but can be used for a wide variety of configurations up to tens or even hundreds of states (although I would not recommend hundreds because then it would probably be difficult to understand). As an example, consider a more sophisticated version of the hotel corridor light in which the light does not simply shut off at once, but dims smoothly during two seconds (so the guest has a few seconds to find the light button again). See Fig. 3. The implementation is done along the same lines as before.

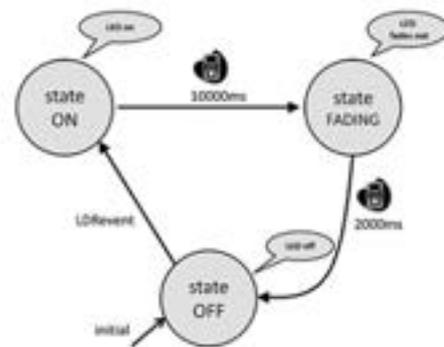


Fig. 3. State Transition Diagram with three states.

STDs have been used in engineering for a long time, see for example [3]. Harel extended them with hierarchy into a formalism called Statecharts [4], which now is also part of UML [5].

### 3 Data Flow Diagrams

Now the example is extended by introducing a second process. Consider a system where the light must go on whenever there is a sudden change in the external light condition. This could be used in an exhibition where the visitor approaching an object on display would create a shadow which would be detected to initiate a

demonstration sequence of the object on display. In this case the demonstration sequence is just a LED going on. A practical sensor for doing this is an LDR, a light-dependent resistor.

Of course it could be tried to include the statements reading the LDR directly into the State Transition Diagram, but I argue that it is much better to have a clear separation of concerns: there are two processes now:

- The LDR process which reads the LDR and finds out whether there is a sudden change in light intensity;
- The LED process which drives the external output, for example the same LED as before.

Parallel processes is a powerful concept. It is essentially multitasking. But when designing the software of the prototype some communication between these processes has to be provided. I like to use shared variables for that.

In the Data Flow Diagram of Fig. 4 there are two processes, each represented by a circle. So depending on the type of diagram, a circle may be either a state (in an STD) or a process (in an DFD). Here in Fig. 4, it is a process. The variables are indicated by the box-like structures. A variable is like a small storage bin to memorize a number, a text string, or a truth value, or even a whole sequence of those. Usually there is information flowing back and forth between processes and variables. The information flows are represented by arrows. For example LEDstep writes its state into a variable called state. And LEDstep also reads and writes its timer. These could be called private variables (of LEDstep). LDRstep signals the occurrence of an event by putting the truthvalue true in a shared variable called LDRrevent. This event in turn is read by the LED process.

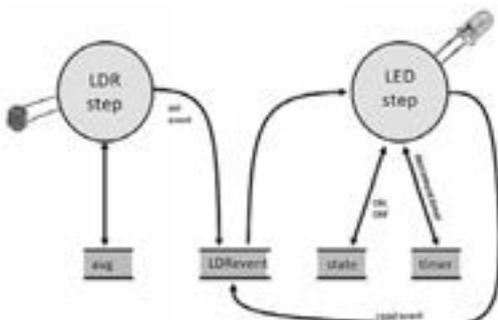


Fig. 4. Data Flow Diagram with two processes and four variables.

Note that also the LDR process has one private variable, called avg, for average. That will be explained later. Data Flow Diagrams have been made popular by Yourdon [6]

Remark: computer scientists have invented powerful alternatives for inter-process communication, such as message queues, sockets and semaphores. Although these are valuable and even indispensable for certain complex engineering problems, the simplicity of shared variables is a great asset during the development of experiential prototypes and 4D sketching [7].

#### 4 How to implement multitasking

Continuing the example I shall demonstrate how these parallel processes are implemented effortlessly. The initialization of the variables determines how the multitasking system will begin its active life. Already when the variable is declared in Arduino language it can be given a begin value:

```
int state = OFF;
int timer = 0;
boolean LDRrevent = false;
```

The LED process is still almost the same as the one of Section 2. The only additions are about resetting the event flag (i.e. the variable LDRrevent). The implementation follows the Arduino theatre metaphor again:

```
void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(ldrPin, INPUT);
  avg = (float)analogRead(ldrPin);
}

void loop() {
  LDRstep();
  LEDstep();
  delay(10); //ms
}
```

For all practical purposes, this gives us perfect multitasking. To be honest, it is not really true parallelism: technically it is so-called interleaving parallelism. Considering the consecutive calls of delay as an "idle process", the three processes alternate quickly as follows: LDRstep is active during about 0.01

milliseconds (or perhaps even less), then LEDstep is active during about 0.01 milliseconds (or perhaps even less) and then the "idle process" takes 9.98 milliseconds. And this goes on forever in an infinite loop. So why do I call this "perfect multitasking for all practical purposes?" This is because for the human observers of this type of experiential prototype we cannot perceive such quick switching between processes anyhow (like in a movie theatre where 24 images per second give an impression of continuous motion from individual images). Moreover, our bodies are not fast enough to make movements which would go undetected by the sensor process. The light condition is checked every 10ms, which is fast enough.

Some readers may be worried by the delay statements and the time wasted by the idle process, so I ought to clarify my position about it: typical embedded processors are fast enough to drive our experiential prototypes and still have sufficient time left. For an Arduino Uno, running at 16Mhz, the processor can spend most of its time in an idle process. The repeated calls of `delay(10)` constitute this idle process, which runs in the background in parallel with the `LEDstep()` process. In the early days of computing, and sometimes even still today, idle processor time is considered to be a valuable resource not to be wasted. Mathematicians may use it to calculate digits of  $\pi$ , for example [8]. In industrial design I am quite happy to waste the processor's time in the repeated application of a `delay(10)` statement. Speed of 4D sketching and peace of mind regarding programming problems are my first priority. Things only become (seriously) more difficult when an Arduino has to do audio or video processing.

## 5 Adaptivity

One of the most important reasons for wanting experiential prototypes to do multitasking is that they have to know what is going on in their environment. Just like we, humans, a smart system, even a not so-very-smart artificial system needs to continuously monitor its environment. This need becomes more urgent when multiple modalities are involved: sensing light, sensing movement, and so on. I shall illustrate this by an example: detecting the presence of humans by an LDR. This is a cheap alternative for camera-image analysis, capacitive sensors, ultrasound distance radars etc. The obvious idea is to choose a suitable threshold value

and test whether the voltage coming out of the LDR goes below or above that threshold.

We humans have an amazing adaptivity with respect to changing illumination levels: we can already see a bit at 0.002 lux on a moonless clear night sky with airglow and already much more at 0.27–1.0 lux when there is a full moon on a clear night. We work in 320–500 lux office lighting and amazingly we are not completely overloaded and saturated at 32,000–130,000 lux in direct sunlight (source: [9]). Precisely because we are so good in adapting, we hardly notice the huge differences around us consciously. That why it is tempting to assume that a fixed threshold in a technical prototype, though not perfect, may be not such a bad idea after all. In practice however, a fixed threshold works miserably and unreliably unless we exert full control over the external light conditions. But wouldn't it be great to equip the experiential prototype with adaptivity?

In this section the earlier example of the LDR-based event detection is worked out in more detail and equipped with an elementary form of adaptivity. The idea is simple: if I would know the average LDR voltage level, then I could use this average as a threshold. The LDR can be connected from +5V to pin A0 with a pull-down resistor of 22k to GND. The incoming voltages should be averaged: that is why our process `LDRstep` has a private variable called `avg`. It is a floating point number, so it can be calculated with some precision (not rounding to the nearest integer). This is how it works: if we have 2000 values,  $V_0, V_1, V_2, \dots, V_{1998}, V_{1999}$ , say then we all know how to calculate the average:  $AVG = (V_0 + V_1 + V_2 + \dots + V_{1998} + V_{1999})/2000$ . Now it is a bad idea trying to store 2000 sensor values inside an embedded processor. An Arduino Uno has only 2k RAM. But I can calculate it in steps keeping track of a "current approximation" of the average.

```
void LDRstep(){
    int v = analogRead(ldrPin);
    avg = 0.9995 * avg
        + 0.0005 * (float)v;
    float delta = 20.0;
    float dif = (float)v - avg;
    if (abs(dif) > delta)
        LDRevent = true;
}
```

So in each step, the new average is mostly equal to the old average, and adjusted a little bit by taking the most recently read value into account. The ideas of "mostly equal" and "a little bit" are made precise by weighing factors of 0.9995 and 0.0005, which are found as 1999/2000 and 1/2000, respectively. The effect is that the more recent values contribute most and that very old values are faded out. Technically, it is a so-called exponentially weighted moving average. In this case the time constant is 20s because this is 2000 times 10ms (the time between sensor samples). It has some resemblance to the idea of a moving time window, but formally it is more like a low-pass filter. And it is very memory-friendly: this one floating point number average occupies only 4 bytes.

Although the software is adaptive now, the hardware is still rigid: one LDR can only give a Voltage range sampled and analog-digital converted to a range of 0-1023 values, so in darkness the Arduino reads 0 or 1 and in full sunlight the LDR is saturated and the Arduino reads a value near 1023. An alternative would be to have a kind of shutter, like the pupil of our human eyes. After all, for us humans, it is not only the brain which adapts to varying lighting conditions, we do have special sensor "hardware" (the pupil). The hardware for my Arduino example consists of two voltage dividers with one LDR each, but with different resistors.

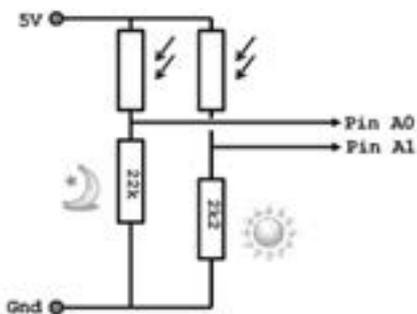


Fig. 5. Sensor circuitry for two light dependent resistors.

Now the multitasking capability developed in the previous section comes in handy. Another copy of the LDR process is all that is needed. Each process can have its own average calculation and event detection. So, when the first LDR is saturated, the other is still sensitive. Or the other way around: when the second LDR does not sense anything yet, the first is already acting. Rather than giving more program code, I

summarize the architecture of this system by another DFD in Fig. 6.

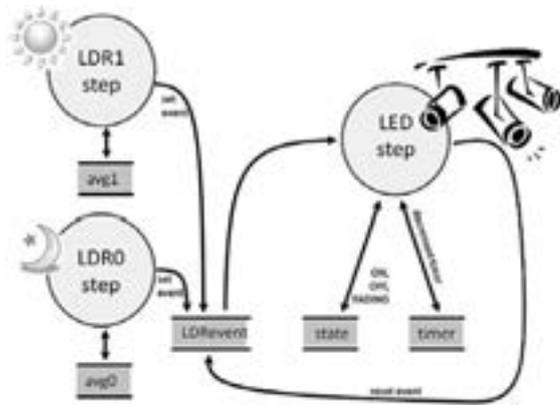


Fig. 6. Data Flow Diagram with three processes and five variables.

The loop function of the system is still extremely simple: just one more step added. The system now has three processes and one idle process.

```
void loop() {
    LDR0step();
    LDR1step();
    LEDstep();
    delay(10); //ms
}
```

The two LDR processes are almost identical, except for their input pins and private variables. There is no extra complexity involved in adding this new parallel task. Even if I would add ten more light sensors, ten temperature sensors and ten moisture sensors, the software would keep its simplicity (I would run out of analog hardware pins long before running out of software resources).

Similar background tasks can make a system adaptive with respect to temperature, fluid levels, a user's heart rate and so on. Also matters of movement in 3D space give rise to background tasks such as calibration and navigation. A system's current position and orientation can be obtained by calculation from sensor data by methods like dead reckoning (developed in ship navigation when sailors had sextants and ship logs only – before John Harrison invented the chronometer).

## 6 Fine grained timing control

It is tempting to assume that the proposed approach only works with processes and timers which are rather slow, such as the 10 and 20 seconds of the examples so far. Fortunately the approach can work with fine-grained time control as well, without any problem. I shall demonstrate how to control a servo motor, as task which requires subtle timing in the sub-millisecond range.

As an intermezzo, let me explain how a servo motor must be handled. A servo motor needs commands which are repeated 50 times per second. Each "command" has to be in the form of a pulse whose width is around 1.5ms. A pulse of 0.8ms means "turn completely left" and 2.2ms means "go to the 180 degrees right position". Obviously 1.5ms tells the servo to go to the central position. In this way any position between 0 and 180 degrees is possible.

I describe the software for a system with two servos. It is a kind of medical-inspired artistic installation where one servo moves as a simulated heart beat and the other a simulated breathing. I show the DFD first in Fig. 7.

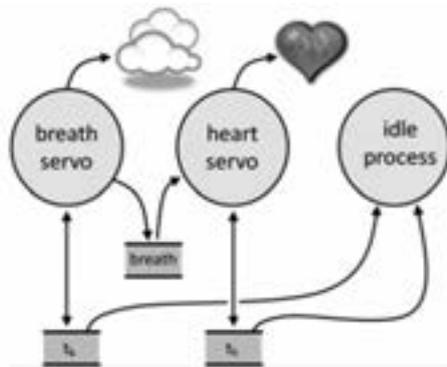


Fig. 7. Data Flow Diagram with three processes and three variables.

It is well known that the breath modulates the heart rate, a phenomenon known as respiratory sinus arrhythmia (RSA). This is modelled by the breath variable between the breath servo process and the heart servo process. Moreover the idle process has access to the fine grained time information  $t_b$  and  $t_h$  of the servo commands. The code fragment shows how this boils down to the implementation level is:

```
void breathServoStep(){
    th = ... ;//between 800 and 2200
    digitalWrite(servoPin,HIGH);
    delayMicroseconds(th);
    digitalWrite(servoPin,LOW);
}

void idleStep(){
    delayMicroseconds(10000 - th);
    delayMicroseconds(10000 - tb);
}

void loop(){
    breathServoStep();
    heartServoStep();
    idleStep();
}
```

In this way I can even control the servo with an accuracy of 0.1 degree (vs. 1.0 degree for standard servo.h).

## 7 Outlook

My claim is that the proposed way of organizing the embedded software in experiential prototypes facilitates highly multitasking systems. Moreover these systems are much more robust and reliable than traditional naive approaches. For example the adaptivity added in Section 4 eliminates the need for hidden calibration potentiometers. It happened that prototypes which worked fine in the design studio fail at the crucial moment of the demo. "I am sorry, but I swear, yesterday it did work" is a story I heard often. Too often. The main reason (apart from unexcusable issues like loose wires and empty batteries) is that the prototype is not adaptive.

Nobody has the evil intention to lead unexperienced design students into the dead-end street of programs which are complicated, mono-tasking and unreliable. Typical Arduino code examples are attractive and low threshold. Yet there is danger. Let me clarify the paradox by showing an example about a servo, which comes with the usual Arduino environment (without the comment):

```

void loop()
{
  for(pos = 0; pos < 180; pos += 1)
  {
    myservo.write(pos);
    delay(15);
  }
  for(pos = 180; pos>=1; pos-=1)
  {
    myservo.write(pos);
    delay(15);
  }
}

```

In principle this is a good program. Yet there is an opportunity for misery to begin when this loop is taken as a template for an extension, include more sensors and actuators. Soon the main loop may contain all the delays, and a cocktail of nested if-else and switch-case statements for a variety of multiplied state transition diagrams. Despite a lot of apparent code complexity, multitasking is still difficult: the Arduino does one thing after the other. The approach outlined in this article prevents the paradox from happening in the first place. At the same time abstract thinking, precision and documentation get better by the proposed STD and DFD.

In TU/e ID I have seen (and sometimes contributed to) succesful examples of good multitasking in areas ranging from fashion to medical simulation. A few examples:

- The "Close-to-you" concept demonstrator and research test tool by Sibrecht Bouwstra of TU/e ID where a visual and haptic information display re-animates a (prematurely born) baby's heart rate and breathing. Multitasking, STD and DFD were all used. The example of section 4 is inspired by Sibrecht's work.
- Perceptive objects by Eva Deckers such as PeP, PeP+ and PeR, capable of sensing their environment, even perceiving presence of a person and his or her activity. The objects have a moving light body which emerges from a multitude of LEDs and are capable of perceptive interaction or even perceptual crossing. The objects are highly adaptive. DFD notation was used succesfully to manage complexity. Eva was awarded a Cum Laude for her PhD [10].
- Drapely-o-lightment, an innovative skirt in high-tech fashion design by Marina Toeters and me. Drapely-o-lightment is about OLEDs and their embedding

in soft fabrics. An Arduino senses the presence of other persons and feeds several (state-dependent) light patterns into the OLEDs. Drapely-o-lightment was shown at Architextiles in Tilburg, Place-it in Berlin, Gouden Geesten in Utrecht, Pretty Smart Textiles Ronse, Belgium, the pop-up fashion show of Amsterdam Fashion week, Smart Textiles Salon 2013 Gent Belgium, TEDx Brainport, and the Bridges Mathematical Art Galleries Enschede [11].

The multitasking approach explained here is not new, and has been used succesfully in traditional engineering projects outside the design community [12], where it is called "synchronous multitasking". It is popular in industrial automation because the programs tend to be more deterministic than programs using the interrupt-based multitasking of Windows and Linux. The determinism allows for better testing and debugging. The main contribution of this article to make such lost knowledge available to the design community again and translate it to our Arduino environment. In the multitasking approach, tasks can be put together in a multitasking way effortlessly: the adaptive LDRs, the heart and breath servos etc. could be blended into a single program as simple as:

```

void loop(){
  LDR0step();
  LDR1step();
  LEDstep();
  navigationStep();
  heartServoStep();
  breathServoStep();
  // more
  idleStep();
}

```

If the reader thinks that the examples are small and simple-minded: yes, *that is the big advantage*.

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# EMjam: Jam with your Emotions

## Abstract

During improvisation, musicians express themselves and their emotions through live music. This project looks at the relationship between musicians during music improvisation, the processes of expression and communication taking place during performance and possible ways to use specific characteristics of musicians, such as emotions, to influence a digital instrument and in consequence improvisation. To visualize this, a three – layer model is described studying the relationship between band members and the audience as a system, where emotions, expressivity and generation of sound give shape to improvisation. Focus is applied specifically on how individual emotional arousal can be used as input to control as a group a musical instrument: EMjam. The instrument is illustrated, describing the design and implementation as well as the evaluation of it, to subsequently discuss the results.

## Keywords

Music, improvisation, composition, instrument, performance, emotions, arousal, expressivity, electrodermal activity, skin conductance.

## 1 Introduction

When paying attention at a concert it is possible to see performers' expressions; a guitarist playing a solo and reaching a peak at a certain point of it;

a bass guitar player following with his face the lines played; a drummer making accents with the whole body; and in addition to this, the audience responding to the performance. At these moments we can see that making music is not only playing the instrument.

There are factors that have an important role on performance; individual expressivity of the emotional experience through physical gestures allows musicians to communicate their intentions and express their emotions towards others. In the same way, interaction during performance has an effect in the arousal of emotions on performers and listeners [1].

Even though the process of making music can be individual, meaning that one person plays one instrument, in a band it is built together by a group playing different instruments. Hence, group members influence each other during performance, either in a physical way through non-verbal communication or through expression of musicians' emotional state.

The work described in this paper focuses on music improvisation, studying the process that requires musicians to communicate their intentions and express their emotions towards band members and audience, by making use of physical gestures and a computer – generated sound.

While an improvisation session makes use of traditional instruments to make sound, there are other possibilities that can add expressivity to the performance, such as the manipulation of sound through physical gesture

to control digital instruments [2, 3]. Emotions are an important part of music improvisation. Musicians play a unique composition that is created in its final form at the specific moment of improvisation, making that a single musical design would sound different on other sessions [4]. Although many musicians draw on patterns and “trademark” sequences of their own when improvising, the composition happens in place, and musicians can externalize the emotions felt at that time. The use of emotions in improvisation to control digital instruments through sensor technology can offer new opportunities that are yet to be explored in the field. This project goes beyond the use of physical interfaces and musicians’ expressions to control sounds, exploring the possibilities of using individual physiological measurements of emotional components, such as arousal, to be used as an input for a digital musical instrument controlled by the whole band; giving musicians a second layer of improvisation and expression.

## 2 Related work

Musicians communicate emotions by means of musical instruments in a non-verbal<sup>1</sup> way through a variety of modalities. Expressivity suggests a process in which musicians externalize their emotions through “expressive gestures” [5]. According to Camurri et al. gestures contain expressive content and convey information related to the emotional domain such as: feelings, moods, affect and intensity of emotional experience; either in an acoustic or visual modality. Gestures can be expressive not only through physical gestures of performer, but include also the produced sound and visual media. Finding new ways of controlling or influencing music using a performer’s expressivity has been addressed in the past [2, 3], introducing a new layer of interaction in the context of musical performance. These approaches focus on proposing new instruments and systems, as well as influencing the sound generated by traditional instruments through the use of a musician’s physical gesture. Furthermore, new applications start to focus on the inclusion of emotional responses through physiological signals for the control of digital instruments. Related work can be seen on [6] where physiological signals (electroencephalogram, electromyogram and heartbeats) are used to control sound in order to build a biological driven musical instrument. Another example is the BioMuse system

[7], which uses on-body sensors to measure motion and physiological signals to determine emotional states integrated into what is defined as an Integral Music Controller. The BioMuse is based on a model [8] describing the number of existing interface devices for controlling a digital musical instrument. Its importance is the addition and consideration of emotions as a controlling interface which introduces a new feedback path within musical performance. Additionally, the BioMuse system covers three layers of feedback that can be achieved in musical performance:

- Layer 1 represents the internal emotion and thoughts of the performer.
- Layer 2 is the physical interface layer.
- Layer 3 represents the creation of music as a consequence of the gesture.

Here, thoughts and emotions are represented through physical gestures that are used to control a sound generator. The resulting sound and interaction create a direct feedback loop. It also considers emotional state and physical gestures from the audience and the possibility to be used to manipulate the generated sound. However, the model proposed by Knapp and Cook [8] focuses on individual feedback loops and interaction with a controller and does not consider the influence of other band members during performance. Interaction within the band is important for musicians and has an influence on improvisation [9]; that is why it needs to be considered. Looking at the structure of bands, a band incorporates several feedback loops, e.g. an individual loop, a band loop and an audience loop; demanding musicians to be aware of different settings at the same time [4]. Designing musical instruments for a band behaving as a system requires a different approach: understanding the organization of musicians during music improvisation sets a starting point to develop new musical instruments for a band behaving as a system. In consequence, it is possible to propose systems aimed to create richer interactions that could influence feedback loops between musicians.

Our approach explores the use of emotional components, especially arousal to control a digital musical instrument as a group, offering band members a tool to help them reinforce the communication of emotions. Authors might disagree when defining emotions, but they do agree on their components. According to Schachter’s theory of emotions [10], an emotional state

<sup>1</sup> Even Vocalists use gestures and other modalities to better express their emotions, apart from using speech and lyrics.

can be seen as the result of the interaction between two components [11]: physiological arousal and cognition about the arousing situation. Physiological arousal determines the intensity of an emotion but not the quality of the emotion itself. The cognition determines which emotion is experienced. Both are considered necessary for the appearance of an emotional state. Within the study of emotions, several approaches and definitions can be described. According to Frijda [12], emotions are elicited by significant events. These events are of relevant significance to persons when they touch upon one or more individual concerns or goals. To Frijda, emotions are then “the result from the interaction of an event’s actual or anticipated consequence and the subject’s concern” [12]. Emotions emerge in a process including the occurrence of events, the presence of concerns or goals that make the event significant to a person and the appraisal of whether concerns are or are not accomplished in the interaction. Sloboda and Juslin [13] describe how an emotion being a scientific construct is inferred from three kinds of evidence: (a) self reports including adjective checklists, rating scales, questionnaires or free descriptions; (b) expressive behavior including facial expressions, vocalizations and body language such as gestures; and (c) physiological measurements including heart rate, respiration, skin conductance, muscle tension, electrocardiogram, blood pressure and electroencephalograph.

Based on this kind of evidence, Sloboda and Juslin [13] mention a study, which shows a consensual definition of emotion based on a review of different author’s definitions. Here, emotions are considered as “a complex set of interactions among subjective and objective factors...” [14], including aspects such as the rise of arousal, generation of cognitive processes, physiological adjustment to the arousing conditions, and behavior “that is often, but not always, expressive, goal directed, and adaptive” [14].

Moreover, Laurier et al. [15] make a distinction of works presenting three different ways that have been used to study emotions in relation to music: (1) The categorical representation is based on basic emotions such as happiness, sadness, anger, fear and tenderness. (2) The multi labeling approach makes use of a wider set of adjectives to describe categories of emotions. (3) The dimensional representation models emotions in a

two dimensional space. On the approach of dimensional representation, Russell’s Model of Affect [16] has generated the most research [17]. This model represents affect (an observable expression of emotion) into a two dimensional space. Here, arousal represents the intensity of the emotion on a vertical axis (arousal – sleep). On the horizontal axis the valence (pleasure – displeasure) represents the quality of the emotion. One of the strengths of this model and its use on the music context is that it represents a simple way of organizing emotions “in terms of their affect appraisals (pleasant or unpleasant) and physiological reactions (high or low arousal) [17]. Our work focuses on a dimensional representation by measuring musician’s emotional arousal to use data as a controlling input for a digital musical instrument. The way musicians experience improvisation gives place to individual emotional states, which can vary within the session. Improvisation is a dynamic process that fluctuates between soft and relaxed compositions to more active and explosive ones as a “ fluctuating wave that rises and falls” [18], which can affect also musician’s arousal. In this sense, arousal being a physiological component can be measured; in order to relate the intensity of musician’s emotional state to the improvisation session.

Studies have linked music to emotions, showing that music has the ability to evoke emotions in the listener, and that the qualities that allow this have been used by composers and performers to convey emotions to listeners. According to Zatorre [19] music is capable of eliciting not only psychological mood changes (e.g. anxiolytic effect of relaxing music), but also physiological changes that mirror the changes in mood. Authors have described the link between emotion and music proposing important theories such as Cooke’s melodic cues theory [20], stating that melodic intervals and melodic patterns have perceptive characteristics capable of evoke specific emotions. Other authors (Kivy [21], Langer [22], Meyer [23] and Justin & Västfjäll [24]) have proposed in the same way theories that are of importance for the understanding of how music can elicit emotional responses.

### 3 Approach

Music improvisation requires musicians to communicate their intentions to each other and to express their emotions to the audience on different layers. Even

though the process of making music is individual, in a group improvisation is built together by musicians influencing each other through communication of intentions and expression of emotions.

With the purpose of explaining the process wherein musicians communicate and express to each other and the audience, three layers are explained in the next paragraphs:

The **first layer** is represented by the music itself. Improvisation has a “hidden communication” [25] where musicians set what they want listeners to hear. Individual interaction with their instruments gives as result an individual generated sound that builds the group improvisation.

The **second layer** is represented by the communication and the expressivity of musicians towards the band and the audience by means of physical gestures. Here musicians agree when to start, stop or change aspects of the music, e.g., the volume. By using body language such as movements, facial expressions, reactions and signs, they can show their intentions. These physical gestures are also part of how musicians express their emotions during performance.

In addition to this, emotions are an important component in music improvisation, as musician's thoughts and feelings on that specific moment are reflected into sounds. Hence, the **third layer** is settled at an emotional level. Musicians experience the music

they make at a point that they could be “surprised or aroused by any musical line exposed to the ears” [26]. Therefore, expressivity is influenced by the emotional state of musicians and it will also influence improvisation. Other external influences like the engagement of the audience with the band might also have an effect on the response of musicians. In this way, all three layers become a process where musicians play together giving shape to improvisation. The emotions evoked during improvisation have an effect on the way musicians communicate their intentions and express their emotions, which will in consequence affect the sound generated by every band member.

#### 4 EMjam

Understanding all this, makes us believe that different components of emotions can be used to control an instrument in the context of music improvisation, opening new possibilities for a new musical aesthetics and expression. Could we use emotional arousal to generate a ‘second layer’ of improvisation? An underlying sound generated and controlled by the band as a system, where one instrument receives input from every musician. Arousal being an emotional component is related to improvisation, and its variations during performance can be measured to control a digital instrument. EMjam uses these measures to give musicians an extra level of expression.

##### 4.1 The concept

In the context of band improvisation where musicians are playing with their own instruments (for instance, guitar, bass guitar, and drums) to make the main layer of music (see Fig. 2); emotional arousal during performance can be used to control a digital musical instrument creating a second layer of music. This second layer is independent from the improvisation itself, meaning that sound coming from the traditional instruments is not affected directly by this layer (as a sound effect would do), but it creates a new input. Additionally, the second layer is defined by the interaction between band members, in a way that the emotional experience of musicians while playing define the sound generated. In this sense, musician's arousal can be reflected into a second layer of sound and improvisation itself represents the interface for playing. In this way, expressivity of the band is reinforced by an individual input based on their emotional arousal.

▼  
Fig. 1. Three layers of interaction during music improvisation.

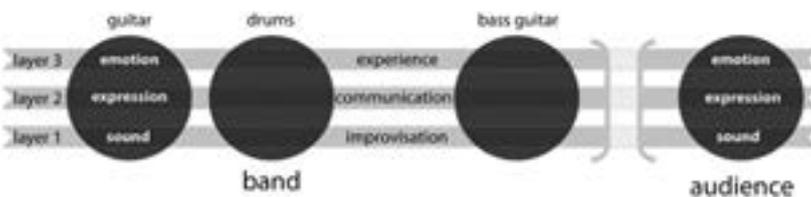
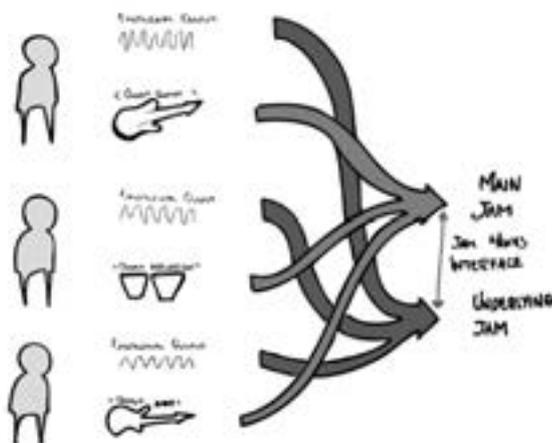


Fig. 2. Two layers of improvisation. Individual musicians' interaction with their instruments results in the main layer of improvisation. Individual musicians' arousal results in an underlying improvisation.



## 4.2 Design overview

EMjam consists of a physical interface and a digital musical instrument.

On the physical interface, three wristbands (Fig. 3, right) hold skin conductance sensors that measure individual changes in arousal. The sensors are connected to a pedal box containing the electronics (Fig. 3, left) and holding knobs for the control of keynote and volume, and a tapping surface for the control of tempo. Measurements from the sensors are received by an Arduino microprocessor inside the pedal box and then sent to an external computer through USB. The digital musical instrument then converts variations in measured arousal into MIDI messages to control specific parameters in relation to rhythm, melody and harmony of an instrument setup.

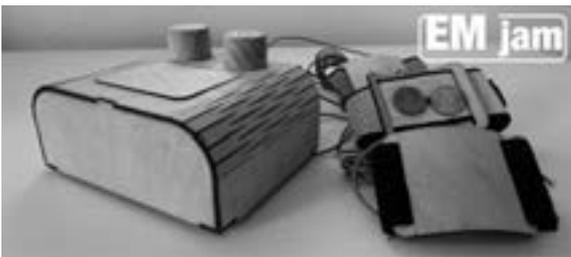


Fig. 3. EMjam. Pedal box (left) for the control of keynote, volume and tempo. Wristbands (right) holding skin conductance sensors to measure changes in arousal.

## 4.3 The physical interface.

Arousal is measured through Electro Dermal Activity (EDA). EDA refers to the changes of the skin's electrical properties when activated by various brain circuits [27]. When experiencing emotional arousal, cognitive workload or physical exertion, the brain sends signals to the skin to increase the level of sweating. Even though sweat is not felt on the skin, the pores begin to fill, increasing electrical conductance of the skin. The most common measure of EDA is skin conductance, which captures changes on emotional arousal. It increases when a person is more aroused: engaged, stressed or excited; and tends to stay low or drop when a person is less aroused: disengaged, bored or calm [27]. Even though different sensors were considered (EEG, EMG and ECG) to measure different components of emotion, we chose to use skin conductance to measure musician's EDA in order to control EMjam for the following reasons:

- The possibility of measuring arousal with a non-invasive and comfortable sensor, to allow musicians to move freely on stage while improvising, without constraining physical gestures.
- The linear relationship between measurements and arousal (high measurement – high arousal) [27].
- The availability of components to build the sensors for a low price.

To control the instrument, three sensors were used (one for every musician) and connected to the pedal box for the control of keynote, volume and tempo. On each sensor, two copper coins were connected to a capacitor and a resistor making a low pass filter. We encountered several problems during the design and implementation of the sensors as 50Hz frequency was interfering with the readings. This problem was solved by changing the capacitor and the resistor which led to a stable reading. Additionally, the speed and reaction of the readings were also improved by putting a silver coat on the coins used as electrodes.

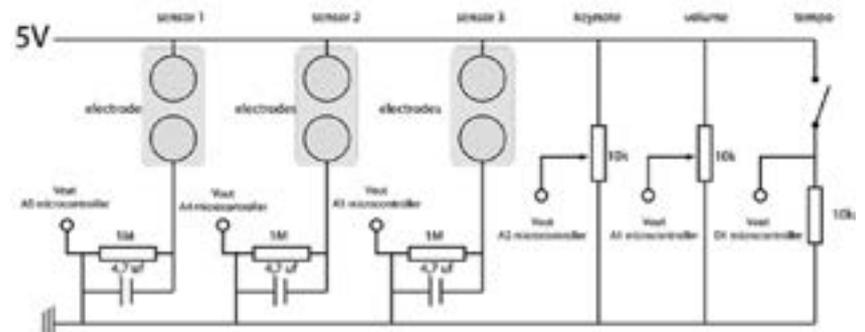


Fig. 4. Physical interface schematics.

## 4.4 The digital musical instrument.

To process measurements coming from the Arduino microprocessor, different software is running at the same time. First, a standard Firmata [28] sketch is used with the Arduino so it can communicate with other software on a high level and convert sensor data from analog to digital. Measurements gained are processed within Pure Data [29] environment, where digital readings of skin conductance and changes in volume, keynote and tempo coming from Arduino (in a scale from 0 to 1), are then converted into MIDI messages (in a scale from 0 to 127). Additionally, it is possible to monitor the readings of the sensors on the pure data sketch. Then, MIDI messages are coupled to Ableton Live where every sensor is mapped to different parameters of the instrument allowing musicians to control them in accordance with their arousal level.

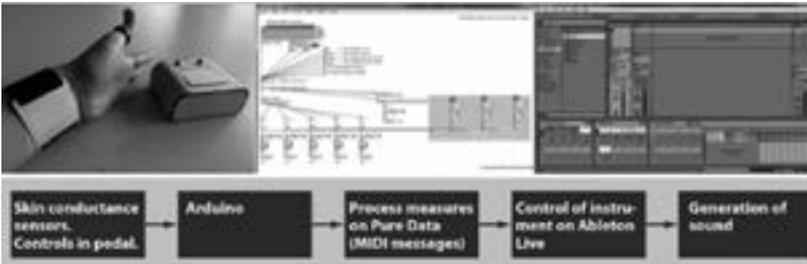


Fig. 5. Physical interface and digital musical instrument.

Parameters of the digital instrument are mapped in a linear way to each sensor, using the following criteria [30, 31, 32]:

- **Start from scratch:** the instrument should be designed entirely trying not to be limited by known and existing instruments.
- **Instrument autonomy:** how much will the instrument do without musicians input?
- **Flexibility:** do as much as possible with few knobs as possible.
- **Interface optimization:** in this case “more is not more”. The number of controllers needed to control a setup reaches a peak at one point, beyond that it becomes noise.
- **Control:** over important aspects of the track.
- **Map sensors in a linear way** (values from 0 to 127) to different parameters that are related to rhythm, melody and harmony.
- **Open:** to make it random yet controllable.

Based on these, the resulting instrument consists of the following MIDI Effect Racks or compilation of effects ( g. 6 and 7):

#### *Rhythm Generator.*

The function of the random MIDI generator is to control the rhythm if the notes triggered. It includes the effects: one Arpeggiator to affect subdivisions of the notes, two Velocity controllers to add accents and cut off the notes and a Note Length controller.

#### *Major Scale.*

This Rack defines the scale in which the instrument will trigger the notes. It includes a Random effect that triggers a note randomly, a C Major scale which establishes the notes that will be played and a Chord effect that makes chords of the notes triggered.

#### *Instrument Rack.*

This Rack assigns an instrument to the notes played and it is a combination of a Muted 1 Pure instrument, which gives definition to the notes and an All Alone Pad that gives Echo and ambience to the setup.

This setup is only one example of a mapping of arousal measurements to sound and other configurations can result in a different sound. In the same way, other digital instruments can be design to direct the setup to more specific music styles.

### 4.5 Mapping of measures to the digital musical instrument

Individual effects that are included into an Effect Rack have several parameters that can be controlled and help to define the sound. For instance, changes on the synced rate (see Fig. 7) parameter of the Arpeggiator will define how many notes will be triggered in a compass. Parameters are arranged into the categories based on basic musical concepts of rhythm, melody and harmony, which are then assigned to every sensor. In this sense, every musician can control parameters on a defined category which assure the richness of the performed improvisation.

The skin conductance sensors were mapped to Ableton Live parameters in the following way:

- **Sensor 1:** rhythm.
- **Sensor 2:** melody.
- **Sensor 3:** harmony.
- **Potentiometer 1:** control of keynote.
- **Potentiometer 2:** control of general volume.
- **Button:** tap to control tempo.

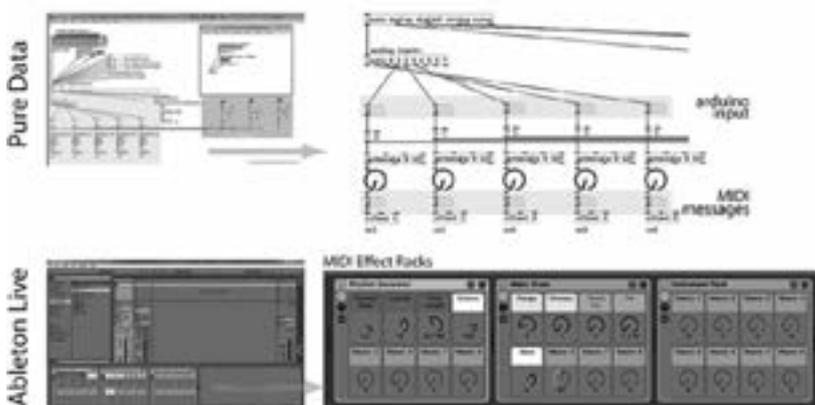


Fig. 6. Digital musical instrument. Measurements are received in the Pure Data software where are converted into MIDI messages and sent to Ableton Live to control the instrument.

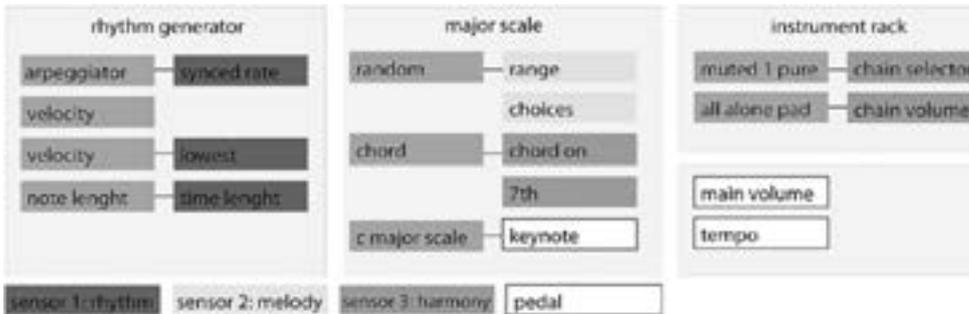


Fig. 7. Mapping of sensors to the digital instrument.

Variations in arousal are mapped in a linear way to Ableton Live, meaning that an increase or decrease in individual arousal will have a proportional effect on the parameters that are assigned to each wristband. In addition to this, the pedal offers musicians the opportunity to control the keynote in which improvisation will take place and the volume of the instrument. By tapping on the tempo controller, musicians can control the tempo of the sound generated on the instrument, giving them the opportunity to adapt the instrument to their own tempo instead of trying to follow the one settled of the instrument.

## 5 Evaluation

The final prototype including the physical interface and the digital instrument was tested with two groups of musicians at Eindhoven University of Technology. They were provided with individual skin conductance sensors to use during improvisation and were asked to interact with EMjam. The main goal of this study was to detect patterns in the way EMjam can be used in relation to the

second layer of improvisation, in order to get insight in the way musicians react and interact with this second layer. Both sessions were video recorded for its subsequent analysis through observation, looking specifically at the engagement of musicians with EMjam, the effect EMjam had on the interaction with other musicians, the general effect of having a second layer of sound and musician's reactions towards it. Notes were taken on the video recording of sessions and the results are as follows:

The first group consisted of three participants playing keyboards, djembe and bass guitar who had never played or made improvisation together; yet they had done improvisation in other occasions, so they had some experience in this activity.

It could be observed that participants were paying attention to the sound generated by EMjam and the sound generated was used as inspiration to build a new improvisation. After improvisation had some structure, the sound became an ambience layer giving musicians a space to play further.

It was noticeable that while trying to keep attention to the generated sound from EMjam, participants were less



Fig. 8. Evaluation of EMjam during group improvisation.

conscious of what other musicians were playing. When they were able to find a line to improvise, attention could be paid to each other. In this sense, responding to the sound generated requests attention from musicians influencing communication between them.

The second group consisted of three participants playing guitar, djembe and bass guitar that had played together before, with less experience in improvisation. In this sense, they improvised on a rock sequence they had already practiced before. Here, it could be observed that the digital instrument was used as a background layer for the improvisation; musicians were playing their own structure and next to it the EMjam generated sound was hearable. As they had played together before, it was noticeable that they had already prepared a basic line to play, which leaved entirely the sound from the digital musical instrument as a second layer of improvisation. Musicians paid more attention to each other instead of the sound generated trying at times to adapt their own volume and tempo to the generated sound.

On this, feedback was given from one of the participants assuring that hearing the changes on the digital instrument gave them awareness of their emotional arousal, as they were able to hear the changes coming from EMjam.

## 6 Discussion

Designing for the band as a group, required an approach where the whole system needed to be studied. The abstraction of the components was helpful to establish a relationship between band members, how they can influence each other and, in consequence, influence the generated sound. In this sense, emotions and expressivity during performance became of importance for the design of an instrument controlled by the whole band. The use of emotional components in the field of music improvisation represents a new feedback path within music performance. It relates the emotions felt by musicians at certain points of the session to the sounds generated, offering a new way of expression. The design of the digital instrument defines the sound generated and makes possible its improvement and its application to more specific music styles such as blues or jazz.

Generated sound from EMjam goes from slow to fast patterns showing an increase on the instruments

activity. Changes on these patterns give feedback to musicians about changes in arousal and the control they have on the instrument, in this sense, slower patterns on the generated sound show less control on the instrument.

## 7 Conclusions and Future Work

This project demonstrated the possibility of controlling sound generators through measure and mapping of individual arousal to a group music improvisation system in Ableton Live, creating a second layer of improvisation defined by the band as a group. This new layer can support musicians offering a tool that helps them by either helping them to break the ice at the beginning of the sessions, inspiring them to build up improvisation or by playing background music as an indicator of arousal. For future research there are some aspects that need attention. The calibration of the system needs to set up a range where musicians can play, making recalibration possible over time. Additionally, musician's interaction with EMjam can be improved by developing the interface further, adding sensors controlled by physical gestures (e.g. accelerometers) to control parameters such as volume, keynote and tempo. New features such as the control of light or visuals can be also included to reinforce musicians' expressivity.

On the other hand, using skin conductance gave an effective reaction on the digital musical instrument; nevertheless, it would be interesting to use heartbeat sensors. Changes on skin conductance can be noticed in a long period of time; by using frequency of heartbeats as input for the system, changes on sounds would be noticed faster and external aspects such as temperature will have less influence.

For our purposes, emotional arousal was mapped in a linear way to Ableton Live, meaning that changes on measurements had a proportional effect on the parameters assigned. Different way for mapping measurements could include logarithmic and exponential functions, to emphasize different parts of the arousal spectrum.

Finally, the scope of the project can be expanded towards the inclusion of the audience in the control of the instrument, by finding ways map their reactions or engagement on the performance to the digital instrument.

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# Project Loci: Haptic Interactions Influence Situational Awareness

## Abstract

Today, technology functions primarily as a means to provide access or give form to information. Personal electronic devices allow us to access this information from almost any place, at any time, yet the most common way to access this information is through screen-based interfaces. Project Loci demonstrates the feasibility of using haptics as a method to convey more complex information – in this case, using a location-aware backpack that provides tactile feedback to the user to indicate the relative safety level of their location. This project demonstrates how integrated haptic technology allows people to receive information in a more intuitive, physical manner beyond the screen.

## Keywords

Haptics; haptic technology; interaction design; human computer interaction

## 1 Introduction

Haptic interactions hold great potential when applied to digital systems as they allow additional ways to experience information. Project Loci was created as a way to explore this potential by using environmental awareness to demonstrate an application of haptic interactions. This project operated in the space of safety and environmental or situational awareness because it represents one area that could benefit the most from

haptic, non-screen based interfaces. Environmental awareness, the cornerstone of safety, relies heavily on the senses, specifically sight and hearing. Both of these senses are severely diminished while using personal electronic devices, most of which are screen-based and provide visual and auditory stimuli. Project Loci uses a backpack, instead of a screen, as a platform to explore haptic interactions. Incorporating these interactions into a backpack removes the users' dependence on a screen, allowing access to complex information through physical perception of tension and movement. Project Loci attempts to provide a practical application of using haptic interactions to create a more intuitive and beneficial method of experiencing information to promote safety and contextual awareness.

## 2 Conceptual Approach

The ability to convey the safety level of an urban area was a key driver for the project, requiring the system to understand and interpret the relative safety level of a location through crime statistics. Crime statistics are typically displayed in the form of tables and graphs showing the types and frequency of crimes in regions and districts. This information can be found online through annual police reports issued by most municipalities as shown in figures 1 and 2. The only way to interact with this information is to read either the charts or maps, which is a taxing experience because of

the density of the content, and this experience is made even more demanding if the reader is on the move.

After establishing a method of determining the relative “safety level” of an area, a haptic interaction was chosen by looking into parental attachment, another safety minded process. It was decided that a tightening grip would work best as a haptic response because of its innate and intuitive feel. The tightening interaction re ected the actions of a child pulling closer to their parent in an unfamiliar situation or environment. Because this interaction is deeply rooted in human psychology, it elicits a visceral response as opposed to forcing the user to make a conscious association between an interface and an abstract concept. This response would be applied to the straps and across the back of the backpack, providing the most surface area for contact with the user. The tightening strap interaction accurately conveys a sense of apprehension, in uences the users’ posture, and encourages a heightened sense of awareness.

Neighborhood	Arrests	Deaths	Injuries	Property Damage
Hillside	12	1	2	15
East Liberty	15	2	3	20
Downtown	18	3	4	25
Northside	20	4	5	30
Southside	25	5	6	35
Westside	30	6	7	40
Eastside	35	7	8	45
Central	40	8	9	50
North	45	9	10	55
South	50	10	11	60
West	55	11	12	65
East	60	12	13	70
Total	400	80	90	500

Fig. 1. The City of Pittsburgh Department of Public Safety Bureau of Police Annual Report (2010), depicting crimes by neighborhood ([http://apps.pittsburghpa.gov/pghbop/10\\_Police\\_Annual\\_Report.pdf](http://apps.pittsburghpa.gov/pghbop/10_Police_Annual_Report.pdf))

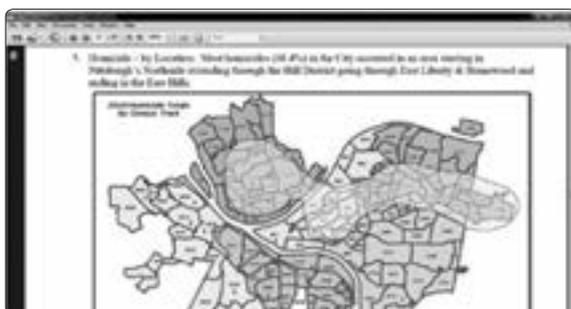
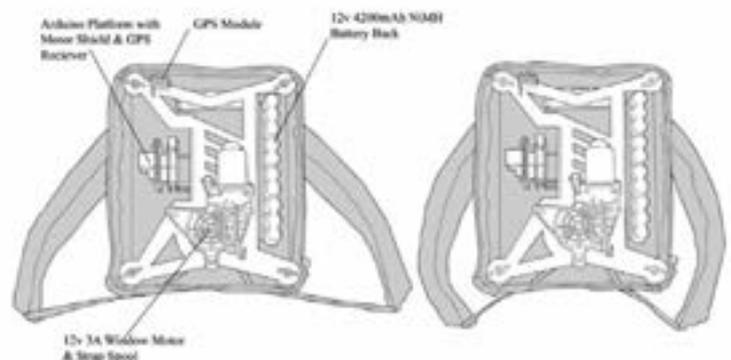


Fig. 2. The City of Pittsburgh Department of Public Safety Bureau of Police Annual Report (2010), depicting homicide rates by location ([http://apps.pittsburghpa.gov/pghbop/10\\_Police\\_Annual\\_Report.pdf](http://apps.pittsburghpa.gov/pghbop/10_Police_Annual_Report.pdf))

The integration of safety level data and information fidelity were additional considerations for the project. Statistical information accessed through digital devices typically has a high level of fidelity; that is to say, most of what is looked at represents finite amounts in the form of numerical, textual or visual depiction. As a result of using the back as the interface between the device and the user it would not be possible to convey high information fidelity. Since the back is seldom used for information processing, any input is quickly recognized due to the peculiar feeling, and is identified. The tightening interaction was chosen since it was determined the relative safety level is more important to display than the actual statistical safety level, which has too high a level of information fidelity to be conveyed through the bag. The tighter the backpack gripped would indicate to the user that their location was more dangerous; the looser the backpack’s straps would indicate that their location was relatively safer. The important interaction for the user would be to experience the action of tightening or loosening, not just the tightness or looseness, because the action would indicate to the user that one area was more dangerous or less dangerous than the previous area. More specifically, the change in state of the backpack’s hold on the pedestrian, the more they are aware of the transition between safe and unsafe areas. The haptic response within this project requires that the fidelity of the information be diminished in order to transmit the information, but in reality considering the context of the user (a pedestrian in motion) no greater information fidelity is really necessary to understand the message. Haptic technology offers the potential to have filtered information (through necessity as it would be impossible to convey all of the information found in a screen based interface through haptics) allowing for the appropriate information to be accessed and processed faster.

Fig. 3. Internal framework and layout of components is as shown without the backpack’s cover. The backpack is depicted unspooled (Left) and spooling or spooled (Right).



### 3 Procedures

#### 3.1 Hardware

The backpack platform for Project Loci is based upon a 12v 3 amp window motor to create the tightening action. The straps were secured to the top portion of the bag and were connected to the motor through a slot at the bottom of the bag where they were spooled around a spindle mounted on the motor. This construction allows for the rotation of the motor to be transmitted as a linear tightening of the straps. The bag utilizes the Arduino prototyping platform to control the bags functions and a 20 channel EM-406A SiRF GPS receiver with 10 meter positional accuracy to determine the bag's location. The motor is powered through a 2 channel 4 amp motor shield supported by the Arduino platform powered by a 12v 4200mAh NiMH battery pack. The components are mounted onto an internal framework within the bag as seen in figure 3. This internal structure is attached to the external shell constructed from molded ionomer foam with a canvas outer skin. The full bag and proper bag positioning is demonstrated in figure 4.



Fig. 4.

#### 3.2 Testing Procedures

Upon the completion of the bag, field testing was used to evaluate the effectiveness of the haptic interaction to the users' perception of an area. The results were not gathered for statistical accuracy, but rather to provide

insight as to how the haptic interaction was generally received, and to provide ideas as to how it could be improved.

Eight subjects were chosen, with an even distribution of gender between male and female. Five of the trials were conducted in the evening around 10pm and the other three trials were conducted in mid-day hours. The evening trials were conducted along a high traffic (pedestrian and vehicle) public urban corridor adjacent to two university campuses in Pittsburgh, Pennsylvania whereas the day trials were conducted on the campus of Carnegie Mellon University. For both sets of trials fictional crime statistics were used to maximize the effect of the haptic interaction by increasing the density of events as shown in tables 1 and 2. The subjects were not informed of the purpose or interactions of the bag before testing, and were surveyed before, during, and after the trial. The subjects were first asked a series of preliminary questions before the study began. The backpack was then provided to the subject who was instructed to wear it for the duration of the trial. A specific course was plotted and followed for the trial and the prompters waited for the subjects to perceive a change in the bag before the second survey was conducted. Upon the completion of the course, follow-up questions were asked and the subjects were informed of the purpose of the bag and the project.

	Location	Crime Level	Longitude	Latitude
A	Webster Hall	3	-79.95127	40.44715
B	Craig St. at Henry St.	5	-79.94892	40.44636
C	Craig St. at Filmore St.	1	-79.94879	40.44527
D	Craig St. at Forbes Ave.	7	-79.94867	40.44444
E	Carnegie Museum of Art	10	-79.94899	40.44376

Table 1. For the evening Craig St. trials five locations were chosen to be points of crime; locations A, B, C, D, and E.

	Location	Crime Level	Longitude	Latitude
F	Hunt Library	10	-79.94372	40.44109
G	Porter Hall	7	-79.94621	40.44174
H	Doherty Hall	3	-79.94431	40.44239
I	Tepper Hall	5	-79.94229	40.44104

Table 2. For the day campus trials four locations were chosen to be points of crime; locations F, G, H, and I.

The bag's tightening system was programmed to be fully tightened (the motor would run full at power for 1.5 seconds) if the sum of the crime levels within a 125 foot radius was greater or equal to 25. For every increase or decrease in crime level, below the 25 threshold, the system adjust 1/25th the full tightness of the system. A perceivable change in tightness or looseness could generally be felt with a 3 to 5 point change in crime level.

## 4 Results

### 4.1 Surveys

Before the trials, subjects were surveyed as to what physical or physiological feelings they usually associated with danger and safety. 50% of the subjects mentioned anxiety as one of those feelings they associated with danger, and 88% of the subjects mentioned calmness or relaxation when referring to safety. When referring to the feelings associated with danger the topic of awareness and tension were mentioned, although with less frequency.

During the trials, subjects were surveyed, as shown in figure 5, as to how the tightening or loosening of the bag, if a perceivable change was felt, made them feel upon entering a predetermined area. 50% of the subjects mentioned an increased sense of awareness or alertness, and 25% of the subjects mentioned being surprised by the interaction, which is most likely due to their intentional lack of familiarity with the project and bag. Subjects were also asked if and how the change in the straps affects their awareness of the surrounding environment. 63% of the subjects described an increased sense of awareness whereas 25% of the subjects mentioned they had no change in their environmental awareness level due to the familiarity they had with the area.

After the trials, subjects were surveyed as to how knowing the purpose and intention of the bag affect their perceived feeling of the walk. They were also asked what they believed the function of the bag was, knowing how it worked and what it responded to. Half of the participants mentioned encouraging safety in dangerous areas. 50% of the subjects when asked if they felt an emotional change while they walked responded that they did not and 25% of the subjects responded that they felt alerted. Across all of the subjects it was

agreed that knowledge and familiarity with an area was a significant indicator of whether or not an area was safe to be in. When the subjects were asked if safety meant staying away from dangerous places or staying alert, 88% of the subjects responded that staying alert was the focus of safety.

### 4.2 Discussion

Discussion with the subjects revealed a common belief that situational awareness was the cornerstone of safety. From this it was also revealed that environmental familiarity would overrule the effects of the bag since users would feel more comfortable in areas in which they are familiar with; as one subject remarked, "I'm going to be more aware in an environment that I know. If I was somewhere I'd never been before, that's where this backpack would be most useful." Surveying the subjects revealed that although the bag represented a more visceral interaction the complete purpose of the tightening interaction did not achieve its full impact until it was explained. Discussion after the completion of the tests, trials, and surveys had revealed that when designing this system there are many different variables that could affect the users' perception of the interaction. Time of day is one of these important variables as pedestrians may be more anxious when walking at night, thus intensifying their perception of the tightening interaction. The point at which the bag tightens in relation to the surroundings of the user is also another important variable that was not considered. If the straps were only to tighten or loosen at intersections, a location that is representative of the opportunity to make a choice, the users' actions may actually be influenced as the interaction may encourage them to choose a different direction of travel. These are variables that would be addressed through additional testing.

The project has acted as a catalyst for the discussion of how digital technology influences common sensibility, information relevance over time, and the nature of "interactive systems". In regards to common sensibility, digital technology has the potential to create user dependence, which on a small scale may not be of great concern, but when applied to a topic such as being able to evaluate potentially dangerous situations, it becomes an issue. Long term use of such a system that relieves the user of this decision making may create dependence, ultimately leaving the user without the ability to use



Fig. 5. Subject and prompter during one of the daytime trials

common sensibility to evaluate dangerous situations or locations. However, it is also possible that long term use of such a system may stand to reinforce the users' "gut-feelings;" proving that an area they felt was potentially dangerous actually was dangerous. In this way, the system may actually act to subconsciously condition the user to the characteristics that make an area dangerous.

The issue of information relevance over time is a major concern with data in digital products. With the ability to access and analyze large amounts of information almost instantaneously, a question is prompted; what is an appropriate time frame for functionally applying data such as crime statistics? When determining the "danger level" of an area, ultimately what is being determined is the potential for additional crimes to occur in that same area. Crime statistics are posted for municipalities annually, most likely for fiscal purposes, and the annual reports were used for this project mostly for ease of access, but this system leaves open the potential for other methods of information gathering. Real time gathering of crime data through dedicated resources, such as community initiatives, or social networking spaces, is nor outside the realm of possibility and represent an inevitable adaptation of this design. The bag prototype proved the feasibility of data mapping in an integrated haptic system, setting the stage for future work where they system can utilize more frequently updated crime statistics sources.

One of the most important aspects of this project is that it starts to challenge the traditional nature of what is considered an interactive system or product. The bag has no buttons, switches, or screens but still remains interactive because the bag represents an entire system that receives input, not just a single product. The system encompasses not only the bag, but also the data the bag uses and the environment from which the data is derived. In this system the user "interacts" with the bag by moving through the environment. In this way the system maintains a form of passive interaction since the bag does require some input in order to receive an output, but the input is not active in the traditional sense of buttons, switches, or conscious manipulation. The system has the ability to provide a wealth of information to the user without forcing the user to dedicate their attention to accessing that information. Through these more subtle interactions the bag starts to speak to the idea that by using ubiquitous computing, previously non digital products can provide less intrusive haptic feedback that is relevant specifically to that product or that product's function. The backpack reflects this as a physical realization of the concepts of transience and personal security, the same concepts embodied in its haptic feedback. As an example, a door knob could heat and cool to reflect the temperature outside, thus alerting the user to what clothing should be chosen to remain comfortable. Computer mice with scrolling wheels could change their physical resistance when scrolling to reflect the size of the webpage being navigated. The backpack serves as a discussion on how information can be observed and accessed in new visceral ways.

There are many different potential use cases for a haptic enabled safety conscious backpack. The most obvious case was explored through the prototype testing with students, but other groups such as tourists could also benefit from the use of this system. With both students and tourists, the backpack allows the user to feel more comfortable exploring their surroundings while discreetly promoting confident decision making. One of the most interesting potential applications of such a system is its military applications. The conceptual space in which the project was originally formatted is relatively low risk, but the system could easily be shifted to cater to a high risk environment. Such a system could indicate to soldiers areas with a high incidence

of attacks, or high potential for attacks, quietly and without forcing them to divert their attention from their surroundings. For a military application this system has the benefit of being stealthy, intuitive, and easily integrated into existing equipment already used in the field.

## 5 Conclusion

Innovations in portable screen based interfaces have allowed us to become incredibly mobile and still have near instant access to vast amounts of information. Unfortunately as we gain access to more and more information on our devices, people become increasingly distracted and lost in the overwhelming amount of data that becomes available. This fascination has demonstrably caused a cultural loss of situational awareness. Project Loci explores the likely future where everyday objects have embedded computing power and communicative properties. Embedded ubiquitous computing allows these objects to provide a subtle, intuitive, and active way of accessing and presenting information, freeing individuals from diverting significant portions of their attention to handheld devices. Unlike the passive nature of screen-based interfaces, these artifacts are able to initiate physical communication between the device and the user providing for more intuitive and natural experiences. They allow people to actively focus on our environment instead of dividing their attention between their screens and their surroundings.

By designing haptic interactions that reflect people's natural interactions with each other, there is almost no learning curve to interpreting the information provided. Leveraging natural and intuitive social interactions allow for information to be presented in subtle and nuanced ways, something screen based interfaces fail to do. Through seemingly simple interactions, information can be presented with a relatively low fidelity, but interpreted at a much higher level because of people's natural understanding of physical interactions between one another.

Haptics enable objects to liberate the user from their screens and enable a wealth of alternative ways to transmit and interpret information. They don't require constant interactions initiated by the user

and allow the user to be present and attentive to their surroundings, instead of dissociating us from our immediate environments like screen-based systems. By being mentally present and aware of their surroundings, people are able to pick up on subtle environmental clues and make more conscious decisions to keep themselves safe. This liberation translates well to almost all aspect of our lives. Given the appropriate form factors and placement in the right context, the fusion of everyday objects with haptic technology can be seamless, intuitive, and help create a more aware and confident world.

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# Smart interactions for home healthcare: A semantic shift

## **Abstract**

A semantic shift is happening in the health industry. Healthcare is moving ever more towards home recovery and care, while time spent at hospital keeps reducing. This is beneficial for patients with faster recovery times and for the health industry through reduced costs. Home healthcare means that medical devices that assist people to look after themselves now need to establish an appropriate communication loop with the patient. There is no longer a focus on the medical device communicating with the medical practitioner through mainly only denotation of meaning. We suggest that the new communication loop implies that the medical device can sense information from the patient's body, it can react to the data gathered and it can communicate back to the patient through denotation and connotation of meaning: making the information relevant for people's everyday lives, addressing pragmatic and hedonic aspects, and not only through the display of data.

This paper analyses a number of medical devices for home healthcare. We suggest a set of criteria that designers can use when designing smart interactions for empowering patients to take care of their health. We present a number of designs from the School of Design, Victoria University of Wellington and assess them according to our suggested criteria.

## **Keywords**

Smart interactions, healthcare, sensing human data, semantics, connotation, medical device design, exergames

## **1 Introduction**

Technology for sensing the human body in the health industries has largely focused on gathering body responses relevant to the medical practitioner. With good reason, the study of human factors in medical devices has concentrated on making sure that user-error was minimised by the medical practitioners. Tongson reported for example on the need to incorporate human factors into the design of analgesic pumps, after a technician entered the wrong setting which resulted in the tragic death of a patient (1998, p. 1484).

Research on human factors which focused on the object's interaction with the medical practitioners has been a necessary field in the design of medical devices. However, there is now a complex challenge to respond to worldwide trends that clearly indicate the move from hospital-based healthcare to home-based healthcare (see for instance, Davis et al., 2010; Koch, 2006; Shepperd et al., 2013; Tinetti, Charpentier, Gottschalk, & Baker, 2012).

There are several reasons for the health industry to move towards home-based healthcare. It has been well documented that patients tend to improve faster at home than at hospitals (for instance, see Eriksson, Lindstrom, & Ekenberg, 2010; Kowalczyk, 2013; Landro, 2010). Depression and infection rates increase the longer a patient stays at hospital (Husaini et al., 2013; Prina et al., 2012; Sheeran, Byers, & Bruce, 2010). A Cochrane study revealed that individualised discharge planning that involves home care brings about “reductions in hospital length of stay and readmission rates for older people admitted to hospital with a medical condition” (Shepperd et al., 2013, p. 2). Home-based healthcare will also help reduce hospital costs in space, equipment and staff hours (see for instance, Feldstein, 2011; Keehan et al., 2008; Koch, 2006; Sheps et al., 2000). Governments around the world are now encouraging and supporting initiatives towards home-based healthcare given the benefits for the patients and for the hospitals.

Home-based healthcare can give a patient independence that comes with the responsibility of taking care of their own treatment. Many patients still need relevant information about their bodies' condition to enable them to make the right decisions and follow the best treatment. While patients are away from medical practitioners, they need medical devices that are focused on gathering body responses relevant to the patient, so that they can be empowered to follow their care with the right kind of information that is relevant for the patient and not unnecessarily technical. The Qual-comm Tricorder Xprize is an example of the move towards monitoring and diagnosing people's health conditions. The prize intends to give individuals greater choices in when, where, and how they receive care. The prize is a US\$10 million international competition due in 2015 to “stimulate innovation and integration of precision diagnostic technologies, making reliable health diagnoses available directly to ‘health consumers’ in their homes” (Qualcomm, 2013).

Technology for sensing the human body is rapidly developing. We can now measure heart rate, breathing rate, skin conductivity, brainwaves, neuronal activity, chemical composition of body fluids, muscle activity, weight, body-fat percentages, among many other aspects of our physiologies. The “quantified self”

movement (Swan, 2009) is a key indicator of the progress and ubiquity of this technology; where all this data is tracked using smart devices and shared and compared online using available social networks (Swan 2012a, 2012b).

## 2 Devices shift from talking to the medical practitioner to talking to the patient

From this point of view and following semantics terminology, the communication loop between medical devices and humans is experiencing a paradigmatic shift where the decoder and interpreter of the information is changing from the medical practitioner to the patient. Similarly, the feedback loop for affecting behaviour change is shrinking: a patient no longer requires explicit advice from a medical practitioner when they can monitor the effects of their actions and intrinsically instigate change in behaviour.

According to the discussion above, we suggest that medical devices that support home healthcare can have the potential to address the following three criteria:

- **Sense human data that is relevant to the patient's condition: what is important to measure?**
- **React to the human data: what should be reacted to and how?**
- **Inform the patient: what does the patient need to know, and how should this information be delivered?**

We suggest that there is a big opportunity for design to respond to the necessary semantic change in medical devices for home healthcare. These devices have the potential to sense human data in seamless ways (potentially through wearable devices), digitally process the data to make it relevant to the patients and present the data through physical or digital reactions in appropriate ways to the patients. We suggest that disciplines such as psychology, health-related disciplines, engineering, industrial design and media design can work together to create seamless experiences to empower patients to take control of their treatments.

This is an area that Human Computer Interaction (HCI) has started to address. Early work on HCI and medical devices followed the same pattern of focusing on the communication between devices and medical

practitioners to reduce errors (for instance, see Iakovidis, 1998; Obradovich & Woods, 1996). More recent HCI research has focused on more relevant gathering of information from the human body. There have even been calls to ensure that HCI technologies have a self-evaluating system to assess whether people perform behavioural changes that improve their health (Klasnja, Consolvo, & Pratt, 2011).

Digital technologies have the potential to translate raw human data into relevant experiences for patients. For instance, videogames that facilitate exercising (exergames) have been used for treating health issues (for instance, see Gerling, Schild, & Masuch, 2010; Sinclair, Hingston, & Masek, 2007; Staiano & Calvert, 2011). Exergames can be used to help patients engage in their own treatment at home. This could be further improved if the exergames offer relevant challenges that depend on the performance of the patients through the tracking of relevant human data. For instance, heart rate could measure how much a patient could be challenged to perform aerobic physical activity, and increase resistance through game difficulty appropriately to customise the recovery rate to the individual patient, or allow them to engage with their treatment socially by playing with other patient players (Muller, 2003).

This paper analyses medical devices that target home treatment where the patient needs to make decisions based on the information gathered and presented by the device. The paper then suggests a framework and a set of criteria for designing medical devices when it is important to shift the semantic dynamics from medical practitioner to patient. We present a set of designs from students at the School of Design, Victoria University of Wellington, and we analyse them according to the criteria suggested. Finally, we conclude suggesting a framework that designers of medical devices may find useful to make sure that their designs offer a relevant communication system with the patients.

### 3 Analysis of existing devices

We have focused our analysis on devices meant to be used by the patient, gather data from the human body and react to the data gathered or present it to the patient. We performed a search on the American Association for Homecare, the US Food and Drug Administration

(FDA) sections on Home Healthcare Medical Devices and Home Health and Consumer Devices, and design blogs presenting real and conceptual designs including designboom, designer, core77, mocoloco.

The American Association for Homecare and FDA highlight the need for devices that help people treat diabetes (blood glucose monitoring and pumps), physical rehabilitation following accidents and strokes (exercising and electronic muscle stimulators), breastpumps and hearing aids. We present a brief overview and analysis of four medical devices that address the initial three criteria of our study: sensing human data, reacting to human data and informing the patient.

**Vitalograph asma-1 PEF meter by CRF health** (figure 1). Vitalograph asma-1 is a spirometer that measures lung function normally used by patients with asthma. It communicates with an electronic diary. The human data measured is lung function. The reaction to the human data is the collection of the information into an electronic diary that sends the data to the medical practitioner. The electronic diary reminds patients when the next reading needs to occur. The electronic diary also reminds patients when to take their medicine. The system intends to be easy to use and encourage compliance and retention. Its automated nature prevents manual data transfer mistakes. The data presented to the patient is numeric and not translated into a meaningful connotation.



Fig. 1. Vitalograph asma-1. Source <http://crfhealth.com/solutions-services/eco-tools/medical-device-integration>

**Able-X by I'm Able** (figure 2). Able-X is a system for treating stroke, cerebral palsy and other brain and arm-coordination impairments (I'm-Able, 2013). The system consists of a bar that is held with both hands

and moved around. The bar wirelessly connects to an exergame designed to encourage patients to move both arms and follow their exercise treatment. The system follows the principle of using the not affected side of the body help the affected side recover mobility and brain coordination. Following our set of criteria, the system gathers data from the human body through tracking movement of the arms. It reacts to the data and presents it to the patient through a screen-based exergame. The human data is informed to the patient through relevant media that offers a clear connotation: movement presented through the videogame. The patients are encouraged and can therefore take control of their own treatment.



Fig. 2. Able-X by I'm-Able.

**Fluenci breastfeeding pump** by Jaap Knoester, Tom Djajadiningrat and Philip Ross ( figures 3-4). Fluenci is a breastfeeding pump that mimics many of the stimulating triggers provided by a baby for a mother who needs to express milk (Knoester, Djajadiningrat, & Ross, 2012). For instance, the pump is heated to resemble a baby and expand the mammary ducts. The pump also mimics a baby's suckling behaviour by starting to pump super cially and quickly to stimulate let down, and once milk starts owing (which for the purposes of this study represents the sensing of human data) the pump slows down and pumps at a lower frequency. The shape of the pump conceals the nipples and intends to avoid connotations of medical equipment.

One of the key factors to consider about Fluenci is the investigation focused on the experience for the mother and her relationship with her baby. It means that the design offers an experience that addresses pragmatic and hedonic aspects of breastfeeding that open a communication loop between object and user. In this case, the consideration of the hedonic experience



Fig. 3. Fluenci breastfeeding pump by Jaap Knoester, Tom Djajadiningrat and Philip Ross.



Fig. 4. Fluenci being used by a participant.

not only offers a more enjoyable experience, but also stimulates the production of milk by the mother by making her feel more relaxed.

**The Aid by Egle Ugintaite** ( figures 5-7). The Aid is a walking cane that incorporates sensors to monitor pulse, blood pressure and body temperature through contact with the hand of the patient. It incorporates an SOS button that can also be automatically activated if the person is in trouble. An LCD displays data and helps with navigation. According to our criteria, the Aid senses human data, reacts to it by sending an SOS signal if necessary and informs patients of their health status. However, the display offers a denotation of the data: it only gives numeric data that may be hard to relate to by the patient. It does not offer a connotation that the patient can interpret according to their everyday experiences.

The analysis of these existing medical devices suggests that we can add the following criterion to our study:

- Use of tangible or digital interactions that enhance the experience from cognitive, behavioural or emotional perspectives through the connotation of information.



Fig. 5. The Aid by Egle Ugintaite.  
Source <http://www.designboom.com/technology/the-aid-by-egle-ugintaite-fujitsu-design-award-2011-grand-prize/>

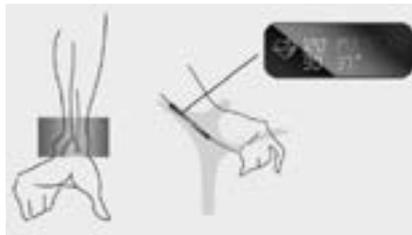


Fig. 6. The Aid and display of human data for the patient.



Fig. 7. The Aid in use.

While traditional medical devices meant to give hard-data to practitioners to help them make decisions, the semantic shift to communicating with the patient needs a more human approach. Able-X is an example of a device that through the use of exer-games not only facilitates exercising, it also encourages it and enhances the experience through the challenge of a videogame that patients can play as part of their exercising. Fluenci exemplifies the opportunity to investigate human experience and design with it as a starting point, including pragmatic and emotional aspects in the design. The communication between the object and the person is different to what breastfeeding pumps used to be when they only needed to communicate with the medical practitioners.

We suggest the following four criteria according to the discussion above:

- a) Sensing patient-relevant data
- b) Reacting to patient-relevant data
- c) Informing the patient
- d) Incorporating a digital or tangible interaction that creates a relevant connotation-based experience

#### 4 Analysis of designs from students at the School of Design, Victoria University of Wellington.

The design curriculum at Victoria University of Wellington is constantly engaging with the forefront of parametric modelling, digital manufacturing, and development of products with an integration of hardware, sensors and software. The unique programme where Industrial Design students can work closely with Media Design and Engineering students fosters an interdisciplinary cohort. We present and analyse against our proposed criteria a set of designs from design students for personal healthcare.

**Cortex 3D** printed cast by Jake Evill (figures 8-10). The cortex system gathers data from the human body through two steps. Firstly, it 3D scans the shape of the broken limb. Secondly, it locates the position of the fracture. The system reacts to the human body gathered data through creating a 3D shape that wraps around the 3D scanned broken limb. The shape also reinforces the area where the fracture is by increasing the density of the material applied based on the location of the fracture. The shape is usually 3D printed and fitted to the patient. This system allows for a cast that is breathable and allows access to the skin for washing and scratching. This system does not offer further information to the patient for their recovery.

**Nexstep leg prosthetics** by Cameron Lightfoot (figure 11). Nexstep is a prosthetic leg that uses neodymium magnets behind the knee to create force and movement, allowing the leg to extend, followed by magnets in front of the knee connecting, locking the knee and completing the walking motion. A similar reaction is repeated in the ankle area. Matching polarity means that the person does not need to swing the leg as the magnets complete the movement. This design does not use digital sensors. It relies on sensing human



Fig. 8. Cortex 3D printed cast by Jake Evill

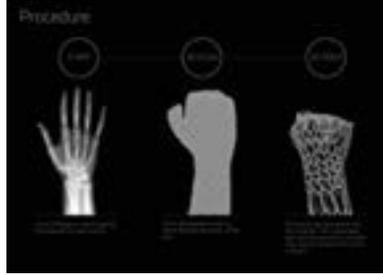


Fig. 9. Cortex 3D printed cast process



Fig. 10. Cortex 3D printed cast detail.



Fig. 11. Nexstep prosthetics by Cameron Lightfoot.



Fig. 12. The Revival Vest by James McNab.

data, in this case movement, and reacting mechanically and automatically to it, giving patients feedback also in the form of movement. There is no hard data to understand, only relevant movement to help people walk again.

**The Revival Vest** by James McNab ( figures 12-13).

The revival vest is a self-inflating life jacket that detects the breathing rate of free-divers, those who do not use scuba diving equipment. When the vest detects that the diver is not breathing, it self-inflates bringing the diver safely back to the surface. While this is not a medical device per se, we find it relevant for this study as it complies with our criteria: it senses human data, it responds to human data and it informs the user allowing them to take control of their own care. If the vest needs to self-inflate, the user has become a patient that needs medical care.

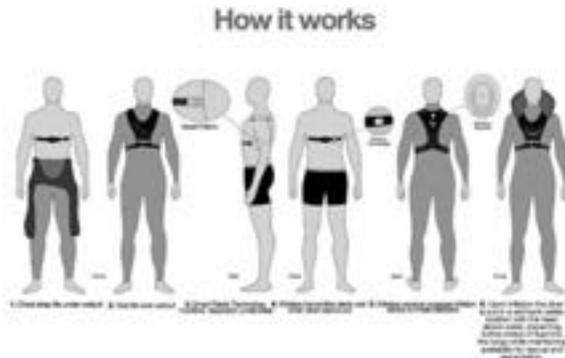


Fig. 13. The Revival Vest process.



Fig. 14. N-One Intravenous pump by Matt Backler.

**N-One Intravenous pump** by Matt Backler (Figure 14). N-One is an intravenous pump that intends to empower patients to leave the hospital, at least for brief periods of time, by offering a portable pump that can be worn on one's arm. The design moves away from a semantics reflecting hospital environment towards a more wearable and jewellery-related type of aesthetics. The pump incorporates an intelligent motor that can sense blood flow, reacting and giving the right dose to the patient accordingly.

While a digital interaction seems to be a promising way to offer relevant information to the patients, very few medical products seem to include it. Able-X is an exception, offering a combination of an exercising device and a set of digital exergames to encourage and facilitate its use. The possibility to offer a digital interaction needs to be balanced with its need and the potential benefits. For instance, the Cortex cast does not offer a digital interaction to the patients beyond the scanning of their limbs which would be carried out by a medical practitioner.

### 5.1 From denotation for the medical practitioner to connotation for the patient

Fluenci is a good example of creating a connotation-based experience for the user, in this case the mother. The device mimics baby-behaviour, making the experience related to the pragmatic and hedonic experience of the mother and not only a practical task of extracting milk.

It is important to note that the semantic meaning of a connotation that an experience can offer relies on its underspecification, which is its context-sensitivity (Dalrymple, 1999, pp. 127–130). While considering the communication between devices and people as a loop serves us as a starting point to develop this initial framework of criteria, it is necessary to consider that multiple loops will play a role in the actual use of the objects. It is the role of the designers to attempt to offer connotations that consider the different contexts in which the objects will be used, as the intended connotation may change meaning depending on the context.

There have been important developments into the design of tangible interactions that focus on the experience of people beyond a screen or beyond presenting data. For instance, the Quality in Interaction group at Technical University of Eindhoven has made great strides towards the research and design of rich interactions that focus on the aesthetics of interaction rather than only on the aesthetics of appearance. If we consider the aesthetics of interaction in the design of home healthcare devices that can sense human data and respond to it, the aesthetics of the interaction can have a connotation type of approach that offers meaningful information and interaction to patients.

Design	Sensing patient relevant data	Reacting to patient relevant data	Semantics inform the patient	Tangible interaction that enhances the experience	Digital interaction that enhances the experience
Cortex 3D printed cast	Yes	Yes	Yes, through the shape	Yes	No
Nexstep prosthetics	Yes	Yes	Yes, through movement	Yes	No
Revival vest	Yes	Yes	Yes, through behaviour	Yes	No
N-One Intravenous pump	Yes	Yes	No	Yes	No

## 5 Discussion

All of the products included in the study sense human data in one way or another. Many do it digitally and then convert the data into relevant information. Others, like the Nexstep prosthetics, sense the data through magnets and react to it automatically and mechanically, without a translation of the data. The increasing technological power to sense human data will only allow us to expand the range of applications for home healthcare.

While some products reacted automatically, others translated the data into information relevant to the patients. For instance, the Able-X exergames are a good example of converting raw data into a meaningful experience for the patients, who do not need to understand what the data is, they only need to be encouraged to perform their exercises.

## 6 Conclusion

Increasing home healthcare and moving away from hospital-based treatment is a tremendous shift that brings important positive outcomes, but it also represents a great challenge for the medical profession to ensure patients are properly looked after and that their treatment and healing is indeed better than at a hospital. From the patient's point of view, while being treated at home may speed recovery and reduce the risk of depression and infections, it can also be overwhelming to suddenly need to know how to treat their condition on their own.

We suggest that medical devices can facilitate home healthcare and offer benefits to patients by offering them relevant information that respects their understanding of the world and their own bodies and medical conditions. In particular and from a semantics point of view, medical devices meant to be used by the patients need to offer relevant information that expresses connotation through items relevant to the patient, and not only denotation through presenting hard-to-understand data.

There is a myriad of questions still to be addressed in this area of design. While we offer a broad initial framework and set of criteria for designing smart interactions, designers will need to investigate deep into specific areas of healthcare and find out the particular challenges for different conditions and in different contexts.

Medical devices can offer important advantages by sensing relevant human data to which they react and/or present to the patients. This can be a process of empowering patients through the intrinsic reward of being able to look after themselves in a more comfortable and familiar setting: their own homes.

In the bigger scheme of things the framework we suggest can have multiple applications beyond the health industries. The interactions between objects and humans can be enhanced and made smarter if industrial and media designers work together with mechatronic and electronic engineers, computer scientists, psychologists and other experts for sensing human data, processing it, reacting to it, presenting it to the person in meaningful ways that involve denotation and

connotation. These interactions can improve people's lives and help them improve their health and recovery. They can also offer more enjoyable experiences through interactions that involve appropriate reactions to the human body. We call this framework Smart Interactions.

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# Design for Elderly with Dementia: Light, Sound and Movement

## Abstract

In this paper we present an interactive lighting and sound art installation designed for the elderly with dementia living in a confined area in an elderly care center. Inspired by lighting and music therapies for dementia, as well as the social and cultural activities of healthy elderly, the installation creates sensory stimulation and natural atmosphere, aiming at bringing joy and happiness to dementia elderly in a dull corridor. The technical details are briefly introduced, followed by evaluation results.

## Keywords

Lighting, sound, music, interactive, installation, elderly care, dementia

## 1 Introduction

Nowadays, the number of dementia elderly is increasing and the pressure put on caregiving is demanding. Research has indicated that the Behavioral and Psychological Symptoms of Dementia (BPSD) are associated with the increased burden of care, which has increased rates of institutionalization of patients [1]. The dementia elderly who live in the care centers have limited access to other people and outside environments. A large part of the life of the dementia elderly is restricted by the lost cognitive ability and decayed memories. Such liabilities determine the passive

roles dementia elderly play in learning activities. Care centers thus provide manually organized activities with clear goals to benefit the recovery of cognitive abilities. However, the manually organized course-like activities cannot extend to a larger scale of daily activities. Emotional and mental wellbeing are not fully taken care of in such settings. Although dementia elderly suffer from some cognitive liabilities, they are eager about happiness and well-being, for which activities in care centers need to be carefully designed and organized.

One of the local care centers of de Vitalis WoonZorg Groep in Eindhoven, expressed their interests in designing a meaningful activity in a corridor through which the dementia elderly stroll from their bedrooms to the common room and cafe. Most of the elderly there are in second to fourth period of disease in their late eighties. The corridor connects bedrooms and common room in which the dementia elderly spend most of their time. The corridor is relatively dark for dementia people where no natural light sheds in and the lighting system keep static and constant. The space is perceived to be dull and boring.

The definition of happiness can be vague and is extremely personalized feeling related to personal background and cognitive ability of emotion. Most researches on dementia define practices that would have a positive effect on dementia elderly's physical and

physiological performance. However, when it comes to design, more investigations into contextual and characteristics of a certain group of people are needed. This project started with looking into the concept of meaningful activities for dementia and its connection to the feeling of happiness. A meaningful activity for the dementia elderly should allow them to experience a sense of wellbeing, a sense of belonging and sustained identity, a sense of continuity of their lifestyle, and their very sense of self [2,3]. Meaningful activities may lead to hedonic and eudemonic happiness depending on whether the activity contributes to a pleasurable life or a meaningful life [4].

The project continued with getting inspiration from the lighting and music therapeutic methods for dementia as well as social and cultural activities of healthy elderly, in order to design such a meaningful activity for the dementia elderly at Vitalis. Several concepts were created and evaluated with experts, leading towards the final concept that was prototyped and evaluated. Next in this paper, after a literature review on meaningful activities for dementia, these design concepts are presented. The final concept and its prototype are described in more detail, followed by evaluation results and the conclusion.

## 2 Meaningful Activities for Dementia

In therapies for dementia, different methods have been used in practice. In elderly care institutions, many different methods are used as well, in order to create activities that are to certain extent helpful or meaningful for the dementia elderly.

Lighting has been used in many therapies for dementia. In general it is found that daily exposure to bright sunlight is an effective anti-depressive [5]. A prolonged exposure to daytime lighting improves the stability of the rest-activity rhythm in the elderly with dementia [6]. Different colored lights might have different effects, for example, blue lights help to let body to produce the feel-good hormone that would contribute to a sense of wellbeing [7].

The dementia elderly may still be touched by music spontaneously be able to sing along with lyrics thought to be forgotten, or even remember how to play an

instrument. Music stimuli may have positive effects on mood and cognitive functioning, including reduced anxieties, increased verbal fluency and spatial reasoning [8].

Reminiscence therapy goes beyond one sense, providing stimulation through multiple sensory channels, such as sound, movement, smell, flavor, changes in light and color etc. Doing so could induce vivid and strong reminiscences [9].

On the website of Opening Knowledge there are many examples of people applying similar strategies in their social and cultural activities in protecting themselves from dementia [10]. Playing piano requires fine motor skills that improve the circulation to the brain, and the “brain work” reduces the risk of dementia (Fig.1). Music activities would decrease loss of hearing holding the development of dementia to some extent, and study shows that daily music-based dance sessions helps patients with dementia significantly (Fig.2). A more active lifestyle with physical activity or exercise helps to prevent a whole number of diseases, including dementia. Physical exercise may increase temporary arousal; stimulating cognitive capability (Fig.3). The results demonstrate the feasibility of achieving higher levels of well-being and diversity of activity for people with dementia. Participants benefited regardless of level of dependency or cognitive impairment. These positive effects might be brought about by the important role of activity interventions related to individual interests. The stimulation of meaningful activities seems to be a powerful intervention both at home and in institutions. [2]



Fig. 1: Hungarian-born Pianist Charles Brunner plays the piano to recapture the Guinness World Record for longest keyboard playing Brunner broke the record of 103 hours and 8 seconds. (Image from Opening Knowledge)



Fig. 2: British DJ Ruth Flowers, 69 years old, mixes music at a recording studio in Paris. (Image from Opening Knowledge)



Fig. 3: A woman balances the "Yue Ya Chan" (Crescent Moon Spade), a traditional Chinese pole weapon, on her head as she exercises in a park in Xián, Shaanxi province. (Image from Opening Knowledge)

### 3 Design Iterations: Lessons Learned from Early Concepts

The project went through three iterations. First two iterations resulted in two design concepts (Fig.7 (a-b)). The concept1 which named Kaleidoshare (Fig.7 (a)) is an object hung on the wall of the corridor, it encourages the dementia elderly to become actively engaged in reliving and sharing their past with others in the present either verbally or non-verbally. As a means of psychological support, reminiscence therapy helps generating a feeling of self-worth and the expression of individual identity. Based on reminiscence therapy, reminders such as personal belongings and familiar music are already confirmed to bring the patients who impair with cognition great satisfaction. Reminiscence therapy is a process practiced to evoke personal memory and experience of the past [12]. When the elderly play with the old disc-like gadget, commonly-interested themes such as children, old-fashioned auto,

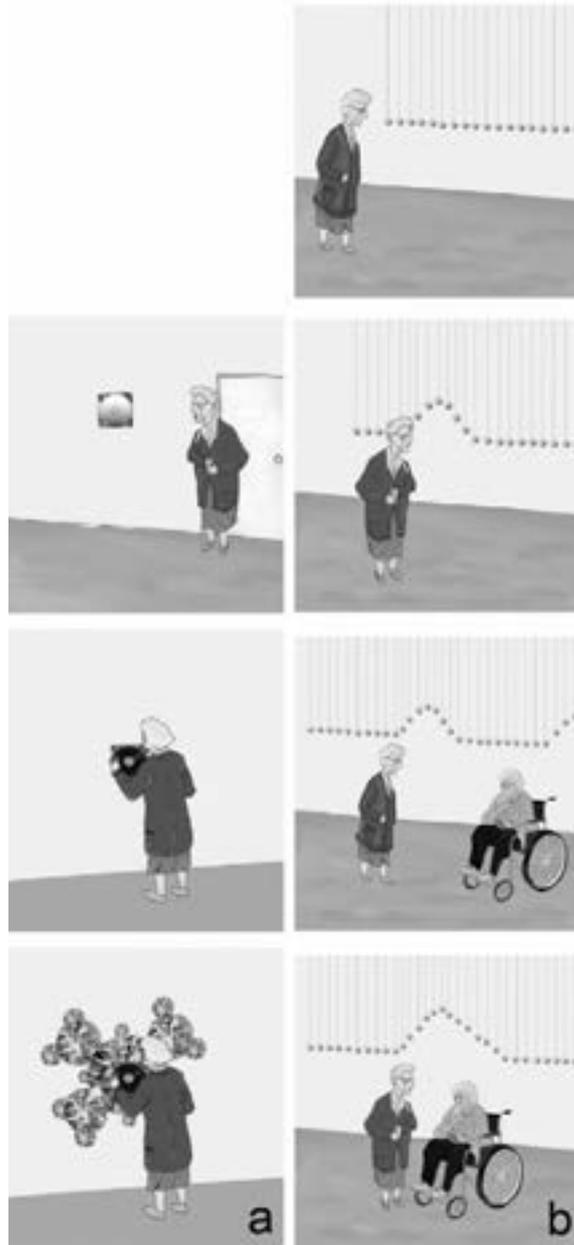


Fig. 10 (a-b): concept1: Kaleidoshare and concept2: Dancing-Ball

scenery would appear on the wall of the corridor. As most of them have trouble to recognize the characters in the picture, such way of common emotional arousal would be preferable to start a short conversation and response among the elderly who encounter each other at the corridor. Next to it, when the elderly rotate the disc, they can feel the speed of the rotation and the feeling of control under their

fingertips. The Kaleidoscope gives glittering bits and pieces of life, and thus when the elderly play with the disc, they can feel actually they are making something beautiful and meaningful to their lives.

However after evaluating the concept with the experts and some elderly, it does not seem to be comfortable for the elderly to stand in front of the wall for a time that might be too long. If the context is moved to sitting place, common room would be more suitable for the concept.

The concept 2 is named Dancing-Ball (Fig. 7(b)). The “dancing balls” would form a mountain shape according to the position of the elderly and the peak reflects the walking manner. The elderly can see that the movements of the whole system are in accordance with their own movements. Because of the different pace and walking manner, everyone would have a different pattern. When two elders come together, there will also be a transaction of the wave.

The evaluation of this concept turned out that it was hard for the dementia elderly to relate the concept to the things they were familiar to. They were curious actually about the things they are familiar to but would like to organize them and work with the concept design in a different way – the concept was too complex for most of them to comprehend.

Based on the first two concepts, the final concept's focus is to bring forward something that offer responses from the surroundings to the elderly, to let them set free to have a feeling of outside world when walking in a confined corridor, and to provide a stage to evoke the liveliness with attention, thinking and responses.

#### **4 The Final Concept**

Inspired by the above mentioned methods and the feedback from the concepts from the first two iterations, the final design concept is to bring in light and sound in an installation to help the elderly to get rid of dull and passive feelings of the confined corridor area at Vitalis. According to the experiment of the first iteration, manual facilitate is needed to understand pictures for the thirds or fourths period of dementia elderly. Vitalis prefer voluntary activities that dementia elders could experience on their own when they retour

the corridor habitually. Considering the circulation function of the corridor, installation should improve the experience for dementia elderly to pass it by. The light and sound are designed in a way to reminiscence the interaction with outdoor nature which is missing in the confined indoor place. By interacting with the installation, the dementia elderly perceive the stimuli that resemble their memories of natural lighting and the sound of water drops with calm background sound of a brook, the experience they miss in the care center. It will be examined in the following test that whether the installations relive outdoor activities in their previous years and whether the elderly are actively involved in.

##### **4.1 Concept**

The concept is to augment the corridor in the confined area with the light and sound from the outside world in response to their movement and touch to help the dementia elderly get rid of dull and passive timeless feelings. The concept is based on reminiscence therapy and implementing lighting and sounds to give stimuli of memorized events. In the interaction, the dementia elderly perceive the response from the nature and they have an active role in making interesting lighting patterns and the sound of water drops. The interaction mimics throwing stones in the river with lights blinking up one by one as the elderly standing in front of the installation. When several elderly present, flowing lighting effect and roaring sounds hints the stirring of ripples.

Sound memory as proved in research, has a strong effect on mood and cognitive functioning until the very late stage of dementia. The feeling of the natural sound of water drops is familiar to everyone in their memories from their childhood when wandering in the wild.

Lighting gives people solid feeling of the elapse of time and the feeling of liveliness. In a dim corridor where the dementia elderly would spend hours every day to walk through, more exposure to light has been proved to be effective in preventing depression and improving rest-activity rhythm.

##### **4.2 Scenario**

The design implements the following scenario: Rob is an elder who suffers at Vitalis. One of the walls of the dull corridor is now decorated with a row of lights covered in curved fabrics (Fig. 4).

At daytime, glowing blue lights gives a refreshing feeling for Rob and the others passing by (Fig. 4(a)). During the night, the light is soothing yellow. The sound of a brook starts whispering gently, which reminds Rob of the fresh air and possibly an exciting outdoor travel experience in his childhood (Fig. 4(b)). Rob hears a chain of water drop sounds coming with the lights one by one. He is fascinated and finds it interesting. He is curious about the lighting and sound effects, and wonders he might be able to interact with it (Fig. 4(c)). When Rob comes close, the first light glows brighter. It glows in response to Rob's position (Fig. 4(d)). Rob touches the light and the touch seems to be sensed. It lights up with solid color with the sound of a water drop. As he walks faster and closer, the sound of the whispering brook becomes louder. The memory of refreshing and playful natural environment comes back (Fig. 4(e)). There comes the other elderly person, Marjolijn, walking in the same direction as Rob. The lights start to flow between Rob and Marjolijn, and the brook sounds running faster. Marjolijn walks closer to the lights slowly, and the lights near her become brighter yet glow slower (Fig. 4(f)). When Marjolijn walks towards Rob instead, the lights flow in the manner of joining together.

The lighting augments the encounter of people and the sounds change as a response to the movements of the elderly just as what happen outdoors (Fig. 4(g)). We expect the multi-user interaction would also improve the feeling of social connectedness [11].

### 4.3 Prototype

The prototype of concept was implemented and tested with the dementia elderly and the caregiving experts at Vitalis. The prototype implements the interaction between two people in the distance, and the effect of touching. Infrared distance sensors are used to detect the speed and direction of the movement, and cap sensors are used to detect touch. When there is elderly walking closer towards the first light, it becomes brighter with the background sound of water start whispering. Lights flashed one by one gradually with water drop sounds. Once the elder touches the colorful plastic area, the corresponding lights lit up with water drop sounds. When there comes another elder, lights between them would flash with roaming water sound.

### 4.4 The User test and Results

The final prototype was opened for user test at 3.30pm, on 20th December 2012 at Vitalis (Fig. 5). Instead of hanging out in the corridor, the prototype was set on a long table in the living room where 8 elders with dementia sitting at another table 2 meters away could see and experience when others play with the prototype.

However, the prototype was only displayed for a relatively short period of time. Moreover the actual concept covered one side walking space in the corridor, and full size of the concept would have an effect on the circulation function in the corridor, which was later discussed with experts from Vitalis.

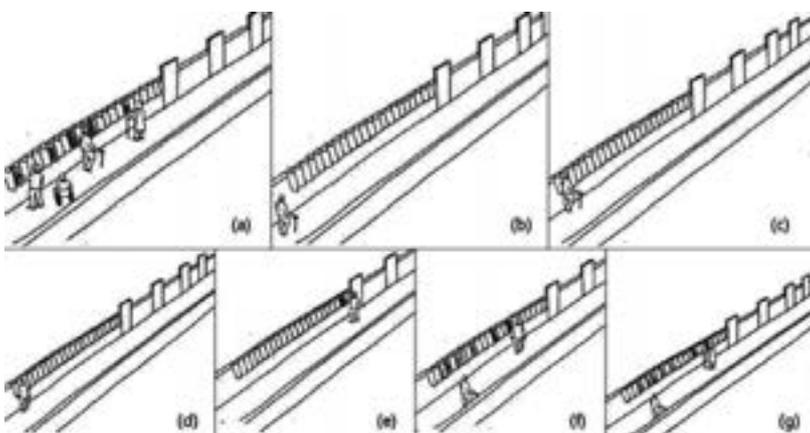


Fig. 4: Scenario



Fig. 5: The final prototype used in the evaluation

### **Mood board**

Creating mood boards would be a useful way to reflect the user's emotion and attitude towards certain concepts or products. However creating such a mood board could be time consuming and, especially for the dementia elderly, very challenging. Instead, the participants in the evaluation were asked to make choices from a restricted selection of images for certain aspects. This supports a more formalized analysis. On the basis of this prototype, the participants were asked with the following questions:

- Which image resembles your mood while playing with the lighting?(Fig. 6(a))
- Which image represents what you are thinking of while playing with the lighting?(Fig. 6(b))
- Which image can recall the memory you once had while playing with the lighting?(Fig. 6(c))

The care givers were asked to observe the dementia elderly also and were asked to answer the following questions:

- Do you think the dementia elderly like the lighting, and in which ways? And how about Sounds?
- Do they behave relaxed or interested or agitated? (positive or negative), and in which ways?

- Does the design make the dementia elderly more active? In which ways?

During the interview, the participants were also asked to describe why they choose certain pictures in order to prospect their thinking.

### **Re actions**

In general, the prototype did bring some joy and happiness to the dementia elderly as expected. The Elderly loved to keep trying and interacting with different behaviors of the installation. They loved to see the glowing and flowing light effects and to hear the curious water drop sounds after they had touched the lights. The experts commented it as "pleasant; the elderly love it; they are not bored any more in the corridor; this provides them with minutes of escape."

During the practice, several behavior patterns are observed: the elderly keep interact with the blue circles of the installation. Interaction among multiple elderly is not active as expected because the elderly cannot perceive the interaction solely on perceiving sound volume and blinking rates.

The elders were fond of the interaction with stimuli such as light and sounds. The installation gave them stimuli for minutes of attention which allowed them escape from the reality into another place in a pleasing way, which was considered by the care givers to be active and healthy. However, the elderly cannot fully relate the sounds and lighting to the throwing stones event when interact with multiple elderly. Thus the voluntary engagement of multiple elderly is not as active as that of the only person.

Except for reminiscence on object, it is possible to relieve the events for reminiscence based on lighting and sounds. Lighting and sounds create a low-fidelity environment and yet effectively vibrate interaction of elderly's past activities. In addition to lighting frequency, the elderly are facilitated by color of lights to grasp instantly what the scenario is.

## **5 Conclusion**

Dementia elderly in the care house spend hours every day to pass through the corridor because basically their footprints are limited to bedrooms, common rooms



Fig. 6 (a-c): pictures help to present dementia to prospect their thinking

and corridors. Mostly, they view the corridor as outside world where they pass through every day many times.

The concept of the lighting and sound installation for the elderly with dementia was directly inspired by the therapeutic methods and preventive social and cultural activities. The prototype of the concept was evaluated and it achieved the goal of bringing joy and happiness to the dementia elderly. Dementia elderly are fond of the stimuli that light and sounds brought up and the natural atmosphere it creates. It gave them several minutes' escape to other place every time they go through the corridor. Direct response to the body movements and respond to touching also attracts them to play with it.

However the scale of the prototype is much smaller than the designed dimension. A more comprehensive user study with a full scale implementation would make the claim stronger.

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# Oris: Bonding through maternal scent

## **Abstract**

In this paper, we discuss the conceptual design of an intimate garment worn by mothers of prematurely born babies that supports the early and continuous bonding between the two of them by exposing the baby to her unique maternal scent. Scientific literature as well as outcomes from interviews with a mother of prematurely born baby and neonatal nurses refers to positive impacts of maternal scent on the psychological bonding between a mother and her child as well as positive physiological impacts on the baby's wellbeing. These outcomes led us to develop a concept called Oris, which through its interactions and functionalities promotes the bonding through maternal scent. Further, we discuss the semantic interaction design applied to the concept as well as metaphorical meaning of a differently envisioned human scent. Further, we propose the application of smart textile materials for collection, sustaining and diffusion of a human scent in different environments. Lastly, we discuss the semantic analysis of the conceptual design.

## **Keywords**

Bonding, maternal scent, semantics, interaction design, smart textile materials

## **1 Introduction**

### **1.1 Early Bonding Interaction**

Healthy newborn babies are able to initiate the first interaction with their mothers [1, 2]. Due to the chemical changes in a mother's body during birth, a hormone oxytocin is released [3, 4]. It is a hormone that stimulates positive caring towards a baby and emotional bonding with a baby [5]. When a baby is laid on the mother's bare skin immediately after the birth (i.e. kangaroo care [6]), the mother's nipples and areola smells the same as the amniotic fluid covering the baby [1, 3, 7, 8]. The baby starts to lick the last bits of the fluid on its hands trying to sustain the environment that he or she was in for the previous nine months [3]. The taste and smell of the amniotic fluid makes the baby move towards the same smelling breast and start to lick it. The first attempt of suckling from the mother's breast is initiated.

Unfortunately this early bonding interaction is not possible when a baby is born prematurely. A pre-term baby usually suffers severe medical problems that need immediate attention from medical staff. As mentioned above the skin-to-skin contact (where the baby is laid on mother's bare chest) is usually postponed until the medical condition of the baby is stabilized. The parents' contact with the baby is very limited during that postponement period. Sometimes parents are allowed to touch their child, talk, sing to it or smell it. However

all this occurs in a constricted environment e.g. through the walls of an incubator so the baby and the parents cannot interact with each other freely. The initial bonding is not developed as substantially as if the baby was healthy and allowed immediate skin-to-skin contact.

Involving parents to contribute to the care of their prematurely born baby and reading the infants behavioural cues increase parents' confidence in caregiving and may facilitate bonding [9]. This may possibly decrease the chance of later disturbances in the parent-child relationship [9, 10]. It is therefore presumed that attempts to facilitate and accomplish this early parent-child bonding may closely relate to an improvement of the physiological and mental development of the prematurely born baby as observed during the execution of the kangaroo care [11, 6].

Research work of S. Bouwstra et al. [12] further analyses the parents-to-infant bonding experience in NICU from the users perspective and proposes the theoretical design framework focusing on experience design as the most suitable design approach.

### 1.2 Axillary Smell Recognition

When a baby lies skin-to-skin on a mother that mother's scent is acknowledged by the baby. This recognizable odour comes from the maternal axillary (armpit) region [13] and neck [14]. In these regions apocrine sweat glands secrete fluid that carries an individual unique human scent [15]. This scent depends on three factors: genetics; diet or environmental factors and influence of outside sources (i.e. lotions, soaps, perfumes, etc.) [16]. Despite these factors a baby can distinguish between his mother's and another lactating mother's odor [13]. Mothers carry their olfactory signature not only from a breast region but also from armpit and neck regions. Such characteristic body odour plays an important role in early child-mother recognition. Further relevance and importance of early olfactory stimulation in prematurely born infants is summarized in M. Croes et al. [17] research work where they also propose examples of implementing improvements in the future research and design in NICU (neonatal intensive care unit) environment.

## 2 User Research

### 2.1 Maternal scent application practices in NICU (neonatal intensive care unit)

An observation study followed by an interview was conducted with a mother of a prematurely born baby in the Máxima Medical Center Veldhoven, the Netherlands. Out of all NICU practices, giving a kangaroo care to a prematurely born baby is one of the closest and strongest contact moments between a mother and her child therefore we chose to conduct the observation study at that moment. The observation study and interview afterwards was carried out in order to find out the mother's perception of her child and any behavioural changes in the child while giving a kangaroo care as well as at times when she is not with her baby, especially in relation to a scent perception of one and another. The mother indicated that she feels good and relaxed while giving a KC to her child; especially she stresses the fact that it is her moment of care. She mentioned that nobody else can give such a care to her child and she feels that they belong together and having a strong moment together. While giving KC, she perceives her baby strongly; she looks at him and calms him down. She perceives the smell of her baby the same as her breast milk. Therefore when she smells breast milk from her clothes at home there is an immediate mental connection with her child. She mentioned that her baby likes her hand over his body and as soon as she takes the hand off, the baby perceives it negatively and starts crying. She indicated that one of the hardest moments in NICU is when she is leaving her baby behind to the care of the nurses. She feels helpless that she cannot care for him by herself. Further, the observation showed that as soon as the child was put on a bare skin of a mother it gradually calmed and relaxed. The baby was in a close contact with mother's skin, especially in an area of breast, neck and towards armpits.

Several interviews with neonatal nurses from three different countries (the Netherlands, U.S. and Czech Republic) were also repeatedly conducted in order to gain insight into the caring procedures and practices related to a scent application in the NICU environment. The main outcome of these interviews was the similarity of one particular procedure including the maternal scent. Across all three cultural practices the nurses supported the mothers to wear either a piece of cotton cloth or a t-shirt overnight and leave that

piece of clothing with the baby in the incubator after their next visit of NICU. The nurses indicated that such practices are either passed on from the senior nurses or they have read about the positive implications on calming the baby or they have experienced the calming effect on a baby by themselves via their practices. In any cases, they support this practice and cannot see it as harm to a baby, quite the opposite.

### 3 Design ideation

#### 3.1 The embodying of scent interactions

Designing with a scent as one of the sensory perception implies challenges. Scent as such may, by many, be perceived as transparent, without one defined shape, color or any other embodiment. Professional perfumers may claim the opposite, since their extensive olfactory expertise is associated with a functional reorganization of key olfactory and memory brain regions, explaining their extraordinary ability to imagine odours and create fragrances [18].

We, as designers usually do not have an extensive olfactory expertise, on the other hand we possess the ability of applying inspirational design methodologies in order to find out about the embodiment as well as interactions connected with the difficultly imagined visualizations. We therefore decided to conduct an Interaction relabeling session [19] with participation of creative professionals from industrial design and human technology interaction domains. This methodology supports the exploration of new interactions by an inspiration from the mechanical properties of an introduced object. These interactions are then assigned onto the conceptual product to be designed, in our case “bonding by scent” product. Participants were also introduced a set of tasks that they had to perform and imagine while using the introduced object. An example of tasks was: “Imagine: how you would load the object with a smell.” “Imagine: how you would preserve as much scent as possible during transportation.” The objects introduced to the participants were as following: an umbrella, mechanical wine bottle opener, measuring tape and vegetable press. One object particularly, the vegetable press Fig. 1, brought the most interesting interactions out of all introduced objects. The vegetable press with its holes at the bottom as well as turning properties of the mashing part that lead to opening and

closing the holes, inspired the participants to think of collecting, carrying and releasing the scent through the holes. Out of about forty ideas, ranging from simple to sophisticated ones, we selected three very sound ideas where participants indicated:

1 – “(The holes could be an) *indication of when a scent is loaded in an object – when the holes are closed the smell is loaded, when they are open the scent is not there anymore. Directly show where in the object the scent is loaded with the handle (of the vegetable presser) and the holes moving into  $\frac{1}{4}$  position,  $\frac{1}{2}$  position and so on.*”

2 – “*The scent could be preserved in some sort of capsules that would fit into the holes. Once the capsules are placed in the holes, turning of the handle can pop the capsules out and the scent is released.*”

3 – “*Preserving a scent could work on the basis of closing itself in and opening itself out by reacting on for example temperature, when it is cold outside it closes, when it is warm it opens.*”



Fig. 1. Vegetable press used in Interaction relabeling session

### 4 Concept Design

Building on the observation and interviews with a mother and neonatal nurses as well as the inspirational Interaction relabeling session, a concept of an intimate garment worn by mothers of prematurely born babies called Oris was developed, Fig. 2. The shapes – “bubbles” – implemented in Oris as well as the interaction with Oris were designed to communicate the collection and diffusion of a human scent in a subtle metaphorical form.



Fig. 2. Intimate garment for mothers of prematurely born babies collecting the maternal scent and diffusing it for a baby. Note two garments in one package and the scent “bubbles” shrunk inside the garment preserving the scent.

#### 4.1 Semantic design and subtle interactions of Oris

The unique design and interaction assist to envision the collection and absorbance of the mother’s human scent and its diffusion for the intended use – her baby smelling it and associating it with a known intimate scent. In the case of Oris little bubbles show “the fullness” by the mother’s scent like being blown and expanded under the amount of scent. Therefore the bubbles became a strong metaphor for the design of Oris and serve as the metaphorical collectors and diffusors of a hardly envisioned human scent. The mother’s scent is collected and diffused only in a warm environment such as a neighbouring area of her neck or in an incubator. These bubbles grow in

their shape once exposed to a warm environment and they shrink once exposed to a cold environment. This “fullness” interaction is also strengthened by the dynamic movement of these bubbles “tearing” their way through an opening in a top layer underneath which the bubbles are embedded. The opening of the top layer and the bubble subtly popping out indicates that the mother’s scent is ready to be exposed (either collected or diffused). On the other hand the closing of the top layer behind a bubble indicates that the mother’s scent is ready to be preserved inside the garment. This very subtle interaction gives a feedback to a mother that her invisible human scent is either getting collected and preserved or diffused. The subtle interactions are communicated in Fig. 3 below.



Fig. 3. Visuals explaining the interactions of the Oris garment

The design of the whole garment (an intimate necklace) is kept very minimalistic and organic. This underlines the very subtle interactions as well its intended use for a natural scent recognition and intimate bonding through scent. The original colour of the bubbles is warm pink which should also represent a warm heart of a mother

being given to her beloved newborn. Later in the development three other colours – soft yellow, blue and green were implemented, Fig. 4. This variety of colours gives a freedom to the mothers to choose their colours for their baby i.e. according to the gender of the baby.

Fig. 4. Oris garments with their distinctive colours



#### 4.2 Intended use of Oris by mothers

Mothers of prematurely born babies do not usually expect a premature baby. A premature baby sometimes arrives as early as even three months earlier than expected. These mothers are neither mentally nor physically prepared to have a preterm baby. They feel fearful about the critical medical state of their baby and are very confused. They would love to contribute to the bringing up of their own child however that is not possible because their child is incubated. For several weeks or months the two of them who used to be one unity are physically and mentally separated.

This is the time when Oris can assist to overcome this separation. Especially with introducing the mother's scent that is already well familiar to the foetus. Oris shall be promoted by NICU nurses because they are the first assistants that the mothers of prematurely born babies are in contact with. The full package of Oris is either purchased at the hospital or at a designated online shop. The Oris package comes with two Oris products in a specially designed carrier box. Mothers can choose which one of the four colours of Oris they would like to purchase. It is recommended to order

always two different colours for later switching one coloured product with another one during the use. The carrier box is also designed in a way that it can keep the mother's scent for a long period of time. Mother starts wearing one of the products; let's say the one with pink bubbles. Her scent is getting loaded in it slowly and therefore she is suggested to wear it constantly whenever she feels comfortable. After at least 12 hours of wearing Oris she brings it to the hospital for her baby. She places Oris next to her baby close by her or his head or where convenient. The warm environment of the incubator helps to diffuse her scent for her baby. At this moment she can already start wearing the second Oris (i.e. yellow) she purchased. Her scent is getting loaded in this second Oris. The next time she visits her baby she can switch the "evaporated" pink Oris for the newly scented yellow Oris. In this way the mother feels actively contributing to her child health care, wellbeing and comforting. Moreover the intimate bonding through scent is initiated and sustained. The whole scenario of intended use of Oris is displayed below in Fig. 5.



Fig. 5. Process of an intended use of Oris

### 4.3 Proposed technology of Oris

The technology proposed for Oris has to carry several properties. It mainly has to be completely harmless to a human being as well as not interfere with the electrical devices used in the NICU environment. Further it should be highly comfortable, soft to look and touch and appealing to its main users – the mothers.

The smart textile material, that we envisage, maintaining the subtle interaction described above is currently the state-of-the-art material. It shall be a specially designed thermal expansion shape memory polymer (SMP) made into threads and later into a fabric. Shape memory polymers are smart materials that hold the capability of changing their shape upon application of an external stimulus - change in temperature [20]. The concept of the shape-memory polymers originates from metallic shape-memory alloys (SMA), used frequently in robotic field, wearable crafting projects and has also been recently introduced in a conceptual medical applications such as M. Croes's Family Arising "hugging" snuggle for prematurely born babies. The shape memory polymers however surpasses the shape memory alloys in their properties related to possible industrial applications, especially in its density and extent of deformation as summarized in Table 1.

	SMPs	SMA
Density (g/cm <sup>3</sup> )	0.9–1.2	6–8
Extent of deformation	up to 800%	<8%
Transition temperatures (°C)	-10..100	-10..100
Recovery speed	1s – minutes	<1s

Table 1. Summary of the major differences between SMPs and SMAs [21].

The shape memory polymers, as indicated above, are currently in a stage of ongoing development. Therefore it is theoretically possible to envision the future development of this smart material towards our proposition where the designed thermal expansion shall reliably operate in a considerably small temperature range between 20° C (room temperature) and 37° C (human skin and incubator temperature). In this way the intended interactions of "bubbles" expansion and shrinkage can be advanced. Diagram below, Fig. 6, shows the envisioned working of the proposed smart material. On the basis of the information we found it is our estimation that given time and budget we could build a prototype and that we are not talking science fiction.

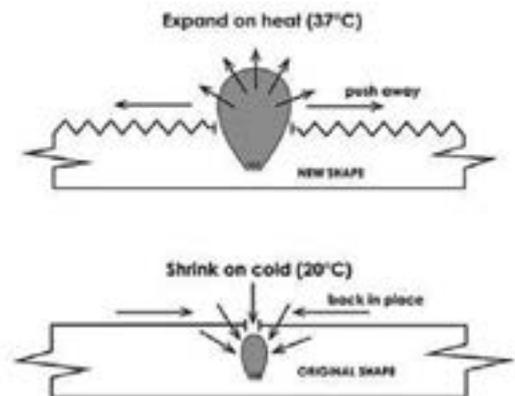


Fig. 6. Envisioned working of the thermally expansive proposed smart material

Additionally, the choice of soft fabric materials is crucial. Not only they should carry an antibacterial property they should be also susceptible to retaining a human scent well. This is a very challenging part of the design however it can be solved by using: bamboo based fabric that has an antibacterial property; and 100% organic sheep wool that is considered to be very suitable fibre material for retaining a scent generally, Fig. 7. This is sustained mainly by the waxy substance of the sheep wool that well binds with the chemical compounds of a scent. One of the major benefits of the proposed technology and soft materials is that it is passive, non-electronic and therefore avoids difficulties of interference and batteries as well as does not cause problems with washing.



Fig. 7. 100% bamboo fabric and 100% organic sheep wool

#### 4.4 Evaluation of Oris

The preliminary Oris concept was visualized in a form of an experience scenario video and evaluated alongside with two other conceptual designs. The evaluation that followed after served as a comparison of the three concepts and affirmation of one that we followed the development with and finalized as Oris. We believe, however, that the outcomes of this preliminary evaluation can serve as an interesting feedback from the users and experts on the actual Oris conceptual design. Thus, we decided to mention the evaluation methodology in short and move onto the actual evaluation results and feedback from mothers and medical staff that we approached.

The preliminary Oris concept experience scenario video was evaluated via an on-line survey with two mothers of prematurely born babies (based in the Netherlands), two recent mothers of full-term babies (based in Czech Republic), one NICU nurse (from Czech Republic) and three medical staff from Gynecology (from the Netherlands). The same video was also presented offline to another NICU nurse and NICU neonatologist from MMC Veldhoven, the Netherlands. The questionnaires were intended to acquire the open opinions on the conceptual design as well as to find out the level of perception towards e.g. connectedness, safety, invasiveness, usability, active contribution to the care and acceptance of the conceptual product when in use.

One mother has mentioned in the evaluation of Oris about the connectedness that: *"It feels that I can contribute to make my baby more comfortable."* In terms of acceptance of the product one mother reacted: *"I like the idea of using heat to capture and release the scent. It is something I would use. Love it!"* One mother was concerned about the product's qualities and therefore mentioned: *"I would be concerned about the safety of the materials. I would only use it if I knew there were no dyes or chemicals that may harm the baby."* In terms of usability most mothers found wearing Oris on a neck very natural and as they mentioned *"it would take little effort to use this product."*

The medical staff has been referring to the connectedness such as: *"It (Oris function) gives a feeling of safety for the baby that it has his/her mother nearby."* When we asked about the active contribution to the care or

feeling of involvement of the mother, the medical staff mentioned: *"It (Oris) gives the feeling of satisfaction to help her baby."* In terms of invasiveness of the product in NICU, one nurse answered: *"I think this (Oris) can easily become a part of the incubators' equipment and be introduced to the health care in NICU."* Few nurses had similar opinion on questions regarding concerns about the product: *"The product could be designed as a positioning aid, since there is not much space in the incubator for too many things."* and *"More flexible use, e.g. as a positioning aid."* Last but not least category has been extracted from the evaluation of the medical staff and that was the product's naturalness. This category has been supported by the comments on the overall Oris concept as: *"Back to nature."*, *"The scent is original."*

Overall Oris concept was positively evaluated by both mothers and medical staff. It was very interesting to find out that the medical staff knew the concept of bonding through scent very well and therefore could identify with it immediately. Mothers on the other hand mentioned that they would gladly wear such a garment if they knew it helps their child. When Oris concept was evaluated with a NICU nurse offline she pointed out that she would like to do an extensive research about how much the mother's scent can calm the baby down. Further, a NICU neonatologist debated whether by designing products that only contain one sensory modality (in this case the scent) might lead into a kind of *"uncoupling of the perception of the mother's whole package"* – the sound of her heart beat, temperature and smoothness of her skin and her scent. From the overall evaluation (when the two other concepts were also taken into a consideration) it appeared that both mothers and medical staff prefer a low-tech subtle design in already high-tech incubators above over-engineered products using lights, sensors, batteries etc.

#### 5 Semantic design analysis

From a semantic perspective, the Oris is based simultaneously on two different approaches to product semantics. The first perspective we shall call "closed semantics" (Fig. 8). It is more traditional yet sometimes a bit unavoidable. It is based on the sender-channel-receiver principle proposed by Shannon for technical communication [22]. The second perspective we shall call "open semantics" (Fig. 9). It is more con-



Fig. 8. Closed semantics according the Shannon channel-coding principles such that the designer encodes messages intended to be understood by the user.

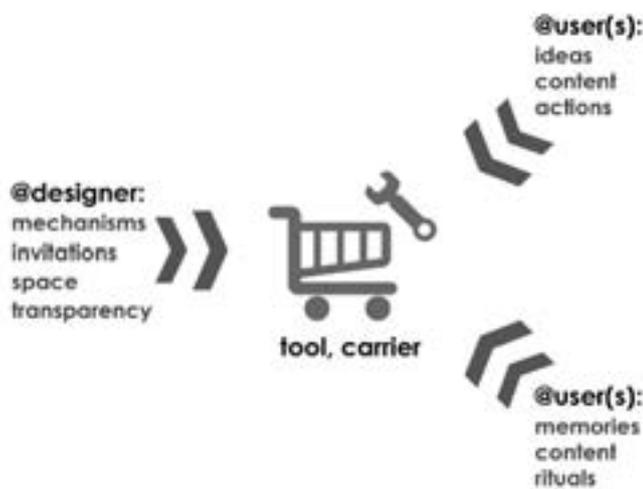


Fig. 9. Open semantics according Krippendorff's "semantic turn" principles such that the designer creates possibilities for the user to load the product with her own contents and meanings.

temporary and much better fit for products which work as a tool, a carrier or a medium. This is what Klaus Krippendorff in his book *The Semantic Turn* explains and illustrates [23]. We assume that the distinction between closed and open semantics is not restricted to the visual modality or to a form, but that it applies for all modalities and modality-combinations including the visual, haptic, auditory, olfactory modalities, interactions, and combinations of these.

Looking at Oris, its design intentions, its key function and the application domain we can claim that first of all, Oris is a carrier in the olfactory domain. It works by open semantics. Note that it would have been possible to design for scent by closed semantics: for example by choosing a scent like patchouli meaning love or adoration. Or sandalwood for protection, harmony or wellbeing (source: [life-style.iloveindia.com/lounge/](http://life-style.iloveindia.com/lounge/)

[aromatherapy-scent-meanings-5330.html](http://aromatherapy-scent-meanings-5330.html)). Yet, that is not how Oris works: the user uploads her own scent, which is an absolutely clear case of open semantics. In fact it is an extension of the purest and most natural example of personalization: the mother's scent is among the very few things familiar to the new born child in its big, strange and overwhelming world (next to perhaps a few sounds such as the parent's voices and the mother's heart beat). Because of this openness in the olfactory domain, any other meanings associated with Oris have to be in the visual, haptic, interactive domain. The audio domain was not included, mainly to avoid electronics with all its difficulties of interference, batteries and so on.

In the (dynamic) visual domain the opening and the closing of the top layer above expanding and shrinking bubbles signifies the possibility of the bubbles to contain scent, to preserve and to protect the scent, and release it. The semantics is mostly of the closed type, but this is done to compensate for the complete absence of any fixed point in the olfactory domain. By metaphor, the visual domain tells about the open-semantics carrier olfactory nature of the bubbles. Further, we have chosen to make the choice of the material (sending a clear message of love, tenderness, being fragile) as the closed type of semantics, which has the advantage that it is fit for the context (either worn by the mother, or when in the incubator next to the baby) and that it informs the user (once again) about the intended application.

But then for the color schemes, the interaction and the packaging, Oris' semantics is very open again. For example the ritual of adopting two colors, such that one is being loaded with scent while the other is with the baby and then the subsequent switching. This is something the mother (and the father) can invent themselves. There are other rituals they can invent with the color scheme, but there are many more rituals and meanings regarding later usage of the Oris. Where to keep it, when to wear it, whom to give it later, etc. etc.

## 6 Discussion and conclusion

A scent is rather difficult to communicate and visualise. However this primarily developed human sense offers a powerful function to be a cue for a memory-retrieval

[24]. The early bonding between mothers and their (prematurely born) babies is crucial for the future physiological as well as mental development of the babies [11, 6] and it is believed that the early bonding has positive effects on the mother and child attachment in later years of the child. Combining the statements above, we could argue that by exposing the prematurely born child with the maternal scent has a positive effect on the bonding between the two of them and therefore creates a cue for a memory-retrieval in the later years of the child. The concept (Oris) presented in this paper is an intimate product with unique semantic features that assists to envision one of our most subconscious human senses – the human scent. Oris is intended to be used as a comforter for prematurely born babies and enabler of the human-to-human bonding at difficult times of separation, as for example a prematurely born baby placed in an incubator for a care after a premature birth.

The development of such intimate products, especially products with scent sensory perception, enable the design and research audience to expand their expertise into this still unexplored field of scent communication and visualisation. In this paper we proposed a design semantic expression of a collection, preserving and diffusion of a human scent in a context of mother to baby bonding. As we discussed earlier in the semantic design analysis paragraph, in closed semantics the designer decides on what messages to inscribe, in open semantics the designer creates a vehicle for meaning leaving flexibility to create meaning by the end user. We believe that our concept proposition can lead to a stronger human-to-human attachment, subtle and poetic communication of a human scent as well as state-of-the-art smart textile material invitation to development.

As with every development and innovation also this concept proposition arose new questions and enquiries for further research and design. To get a solid affirmation that a mother's scent has the potential to calm a baby down there needs to be further studies done. However this arises new questions as i.e. How to measure stress or calmness of a baby? How to distinguish a mother's scent from other stimuli so that the only scent is calming a baby? Is it not confusing the baby if it is exposed to the mother's scent only and not

to other stimuli as her heart beat, warmth of skin, her voice, etc.? Additionally it might be necessary to find out how much of a mother's scent should be captured and diffused for her baby? How often and in which situations is the mother's scent the most efficient for calming a baby? How long does it take to capture "enough" of human scent to calm a baby? Also what role the father's scent plays in comforting a baby? Further designs can be oriented towards mothers as in to capture a baby's scent for her or his mother to support the expression of the breast milk. That arises additional questions how much the scent of a baby can contribute to a more successful expression of her or his mother's breast milk? Also it might be appealing to have a look at designing a comprehensive thought through device based on the mediated intimacy theory. Moreover as seen, the Oris concept initiates more and more new questions and opportunities for further research and design.

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# Experio: A Laser-Triggered Dance Music Generator

## Abstract

In the field of Industrial Design we are moving towards a paradigm of 'Designing for Systems', which means designing from a multiple users/multiple technologies perspective. As this is rather uncharted territory we explored how to design for systems inspired by fields with roots in facilitating behavior and personalization; in this case improvised music. While traditional musical instruments and performances are played by musicians with a certain training skill set, participatory musical instruments are still a challenge as they should allow for a low entrance threshold, easy and fun operation, and the possibility to create appealing musical experiences that go beyond an initial rush. We designed a setting in which people can express them while being part of a bigger technology-mediated musical organism, specifically aimed at 'the whole' rather than 'the sum of the parts'. The design is called Experio; a system that uses laser-triggered dance floor segments to generate dance music. A small initial user test has been carried out to evaluate the possibilities of Experio in a real-life setting.

## Keywords

Musical experience, improvisation, free body expressivity, system.

## 1 Introduction

In Industrial Design, we are moving away from the traditional paradigms of 'Designing for Appearance' and 'Designing for Interaction' towards 'Designing for Systems'. This paradigm breaks with the current interaction structures of people and technology and deals with 'multiple users using multiple technologies' in a highly networked setting. As this design paradigm is still relatively unexplored we need to explore 'how to design for systems', as we experience that we cannot simply adopt the tools and methods from the two other paradigms and apply them to the new one. As an exploration we try to learn lessons from fields with roots in facilitating group interactions, in this case improvised music. In improvised music, individual people performing together are genuinely more than the sum of the parts; they act as a system [1]. Multiple feedback loops between musical instruments, players and the audience complicate this design challenge.

Inspired by this phenomenon, the design challenge aimed at designing a setting in which people can express themselves musically, mediated by technology, while being part of this bigger musical-social organism. In other words, designing an interactive musical instrument that was specifically aimed at 'the whole' rather than 'the sum of the parts' was the final goal of the project. One can notice a diversion from what already exists in the field of musical instruments, as, for

instance, a keyboard is designed so that it can be played as a part of a system, such as an orchestra, but it can also be an experience itself. Instead, the design process started with defining which benefits are desirable in a musical system, then the roles of each single input were given. Such an approach led to the creation of a genuine musical interaction set.

### 1.1 The structure of a live performance

As a starting point, we analyzed what a contemporary musical system involves specifically, in order to be able to carry it over to a futuristic and experimental stage. To this purpose, several students of a music academy who are experienced in rock and popular music were interviewed. They all agreed on the fact that a live performance is generally based on four entities: band, band member, instrument and audience. Each entity is part of the system shown in Figure 1, which also illustrates the reciprocal relationships between the four entities. The missing direct relationship between the audience and the instrument (shown in grey), in which the two entities could have a reciprocal positive influence, could be mediated by technology, thus framing the challenge in this research project.

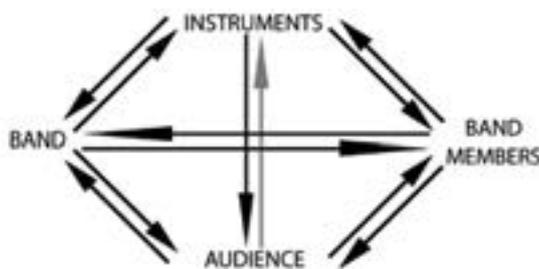


Fig. 1. Interactions during a musical live experience. The grey arrow indicates the missing link.

### 1.2 Related work

Experio was influenced by several related works. In the broadest of lines we stand in the tradition of Louis Theremin, who was arguably the first inventor of a touch free user interface [2]. In basics however, Experio is more related to the 'Music Composition Game' of Chung [3]. First follow the selected beat with a certain tempo, then create a melody above the rhythmic passage, and complete the piece of music with adding a chord layer; the rhythm, melody and triad chords are interrelated. Experio provides a whole new environment in which the moderator in the middle

is responsible for the final musical output, mediating participants' live input with the overall "design" of the experience. In the study of Gates in DJ's perspective and interaction, DJs were asked about how they like to work. Timothy Wisdom replied: "one good tactic is to satisfy 'key dancers' who will help raise the excitement level in a room, causing others to join in on the dance floor" [4]. In Experio, there are also key dancers who are supported by the system to act and dance on the platform around the moderator. The people on the platform will dance and raise the excitement level in a room, seducing bystanders to join them. As inspiration for Experio, the laser harp from D. Rubine and P. McAvinney is used as well. It is one of a number of generalized musical instruments, which allow real performance on MIDI-driven systems and also investigate the possibilities and necessities of interaction between performer and instrument [5]. Finally, there is also extensive related research about multi-user systems and audience participation, for instance, the work of Jordà [6] and Maynes-Aminzade et al. [7].

## 2 Experio

Experio is a new interactive networking design aimed at a more active relationship between the audience and the performer of modern electronic music. The purpose is to let the people from the crowd have an influence on the sound, so that they can take on responsibilities and shape their own experience. Three entities do interact as a system [8]: the crowd, the crowd musicians and the moderator. The crowd is a general term for people who are dancing in a club and enjoy the music. The crowd musician, also named audience performer, is a person who challenges herself with a new way of interacting with the overall music experience, while the moderator is a professional musician who works with by the audience performer's input. Experio is designed such that multiple crowd musicians can interact at the same time.

The Experio setup in specific consists of a big round platform with the moderator standing in the middle. The platform consists of several planes made by laser light, from center to outer rim, like sectors of a pie. In the center, the moderator selects music content, which is partly played directly, for instance the beat, and partly assigned to the different sections of the

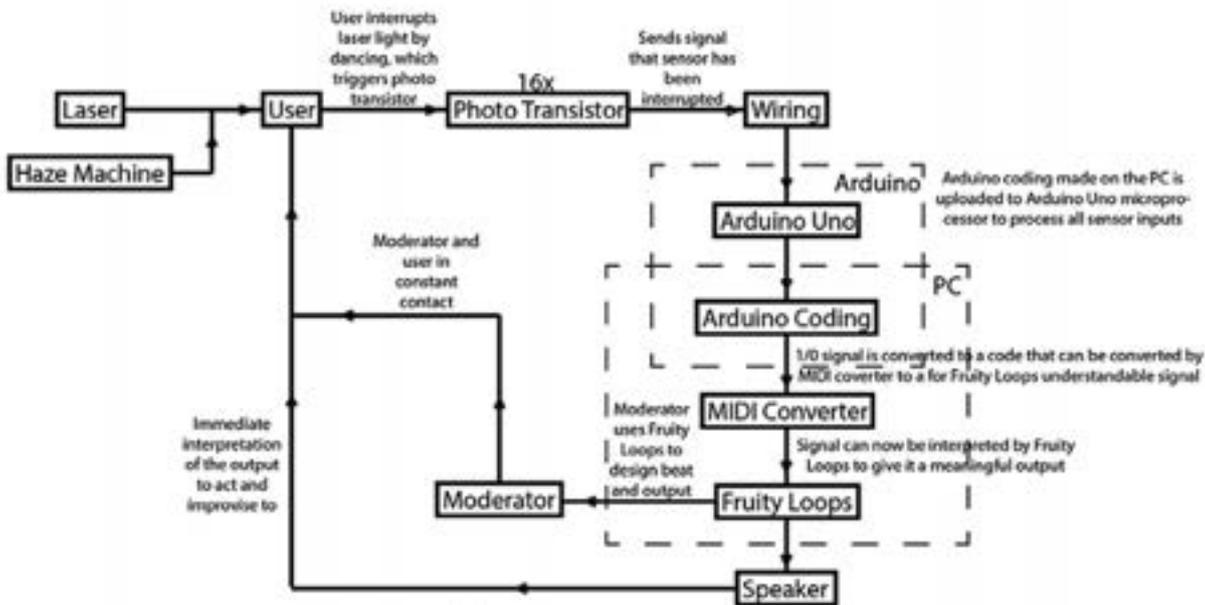


Fig. 3. Schematic overview of Experio.

circle. Each section of the circle will get a different function, for instance, a different sound or sound effect. So, a few people from the audience can step in and dance in the sections. While dancing, they interrupt the light with their feet (or any other limb) and this triggers sensors, which then leads to different musical output. The moderator mixes the inputs received from players into the overall sound scape. As an example, besides playing a drum beat, the moderator will assign to three different sections three different interaction possibilities: a lead guitar, a synthesizer and a reverb effect. He does design the whole music piece anymore, but he is designing the configuration of the instrument with which the audience will perform. After a certain time period the moderator can decide to have another beat and to change the mapping of sections and sounds. The final outcome will be a balanced selection of pleasant, homogenous sounds and more

experimental, daring sounds as inputs, which are turned into something new by the audience. The challenge for the moderator is certainly to select not only inputs that please the audience sonically and will most likely blend into a pleasurable experience, but also inputs that trigger and inspire the audience to play with them. Compared to a common DJ, this gives away parts of control over the entire experience to the audience with the desired outcome of more crowd participation in the creation of an atmosphere. The music performed with Experio can certainly vary, however, for the first performances and experiments beat-centric dance and techno sounds were chosen.

Experio is designed to be quite portable and it can be placed in many different environments with a clear (semi-) circular space. Festivals are very suitable for this kind of experimental music and Experio should add extra value to such a musical event or even become one in itself.



Fig. 2. Experio: the physical prototype.

### 3 Implementation

Experio is built of multiple linked components, which will be shown in the following (see also Fig. 3 for a global view). A laser machine projects a line hovering over the ground and is made visible using a haze machine. The light produced by the laser is being detected by sensors on the other side in a circular prop fixed to the ground. If light falls on the sensors, nothing happens. But as soon as the light is interrupted, a MIDI signal is being sent to

a music software program and this signal can be mapped to musical expression, to trigger a certain sound or to apply a sound effect to a track or pattern. Because the laser-projected line is based on high speed sweeping, the light falling on the sensors is not continuous.

This fast flickering is filtered out with software resulting in one continuous input. The pre-processing is performed on an Arduino<sup>1</sup> chip, which in turn is connected via a MIDI (Musical Instrument Digital Interface) to the music software. For the prototype, Fruity Loops<sup>2</sup> was used as a digital audio workstation to provide the musical output. The current prototype's Arduino chip is capable of controlling all necessary processes for this prototype, but in order to monitor more than the sixteen sensors that are used in the current model, the sensor inputs on the processor need to be multiplexed first. A faster processor is necessary to convert the many fast triggering multiplexed inputs into a stable midi signal and to keep the delay as low as possible. Figure 3 shows a schematic overview that illustrates the workings of Experio, and explains and details the individual components and how they influence each other.

#### 4 Evaluation

As a preliminary evaluation and to fine-tune the interaction with the prototype, we set up an explorative user test, in which users were asked to behave as audience performers. Fifteen people took part in the evaluation, all Industrial Design students; eight of them had a musical background, seven did not. The user test started with an intake questionnaire, asking the participants about their experiences with music and about their first impressions of the prototype. After this, the participants were free to interact with the prototype, experiencing it in order to provide more specific answers during a debriefing interview.

Although the overall interest of the project lies in the generation of a new musical experience, the focus of the interviews was mostly on the ease of use of the prototype, as in this stage we wanted to find out any usability issues that may hamper free expression. The goal was to understand if the connection between the body movements and the sounds produced was intuitive enough and how much time it would take to acquire basic performing skills in Experio.

Most significantly, our interviews showed that there was a need for a more evident strong and not too complex beat, which was considered the most important by the participants in order to dance and improvise to. Due to an unclear beat in the experiment, almost all participants moved very unnaturally and had therefore clear difficulties in looking for a way to dance and improvise. With this in mind, the role of the moderator became more interesting: by putting her in charge of the beat instead of (one of) the participants, the resulting beatline generally becomes more coherent and allows the dancers more freedom to express themselves without having to worry about rhythmic coherence; the moderator in turn is allowed to compose beats freely as well as its associated tones as input for the dancers.

Another important observation was that each participant needed to be able to hear his or her own input in order to be able to effectively improvise. This observation was already made in an earlier stage of the project, but was even more clearly reconfirmed in this user test, as this prototype had a higher level of realism.

A last significant observation was that input provided only by the feet was apparently enough to be musically expressive. One could argue that this might prevent users from reaching a freebody expressivity, but many of the interviewed pointed out how difficult it already is to improvise and contribute to the musical output with limited possibilities, given the short amount of time available for understanding the basics of the interaction. Of course we cannot predict longterm effects, for example, the extent to which the interaction remains interesting – based on this test, but the signs are positive. Apart from these fifteen participants, dozens of other dancers tried out the prototype freely and informally during two two-hour sessions and the response was generally enthusiastic.

#### 5 Conclusion and discussion

In this paper we described Experio, a system design, in which two parties cooperate in creating music. The moderator provides a rhythmic and tonal building blocks and the audience shapes the final sound by their bodily interaction. The intended result goes beyond **being the sum of the two parts alone: in fact we believe that the final atmosphere based on the collaboration**

<sup>1</sup> <http://arduino.cc>, last retrieved on August 10, 2013

<sup>2</sup> <http://www.image-line.com/documents/flstudio.html>, last retrieved on August 10, 2013

between the parts goes a lot further since both parties involved co-create a new musical experience based on reciprocal influence, mediated both technologically as well as socially. We believe that Experio can be considered as an interesting way of improvising in a safe setting, in which people can get familiar with the instrument in a considerable amount of time.

Our preliminary evaluation shows potential to carry on the project into a more extensive and complete working prototype, and considering what is already implemented, a 35 degrees wide Experio (instead of a full circle), and a laptop used as moderator interface, the next step would be indeed to design the moderator interface, a process that will start with interviewing professional musicians and DJs. The focus will then be on developing more, better content for the system as well as finetuning the sounds effects. Apart from this, more open user tests will be carried out – in less controlled settings, for instance, at public exhibitions and also regional music festivals. We believe that these events with their diverse visitors provide great opportunities to further test and develop deliberately open systems such as Experio.

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# Sentiment Ninja: Sentiment Mining on Twitter based on Topic and Location

## Abstract

Social media have become increasingly popular in recent years. The amount of data makes it hard to get an overview of what people are saying. We designed an app that allows users to get an overview of big data on Twitter. We allow users to explore opinions by searching for keywords and allowing them to filter the results based on location. We believe that this application might be interesting for many different target groups such as consumers, companies and journalists.

## Keywords

Sentiment analysis, opinion mining, twitter, map, visualization, big data, mobile

## 1 Introduction

In recent years, social media have become a part of everyday life for many people. Social media allow people to share thoughts, opinions, information, pictures and video with virtually anyone in the world. One widely used social media platform is Twitter. According to the Statistics Brain [1], there are over 550 million Twitter users sharing an average of 58 million Tweets every day. People also use Twitter to search for information: on average, 2.1 billion different queries are issued each day. The massive amount of available Tweets makes it hard for people to get an overview of others' opinions.

Our goal is to provide people with a tool that allows them to get a clear overview of opinions on Twitter in an easy manner by searching for keywords and filtering results based on location.

Our application allows people to query Twitter with keywords and search for results for a specific location. After the query, the application returns the Tweets for the specified location and sorts them according to their sentiment. The results are then displayed in a pie chart on a map to provide an overview of the opinions on Twitter about the queried keyword in the searched location.

## 2 Design and Implementation

In this Section we focus on the design concept and its implementation. Subsection 2.1 discusses the concept, Subsection 2.2 provides an overview of the technologies that we used and Subsection 2.3 shows how we implemented the design concept into the application.

### 2.1 Concept

Sentiment Ninja is a mobile application that allows users to retrieve Tweets from Twitter and sort them according to their sentiment. Tweets are classified into one of three categories: positive, negative or neutral. When users issue a query, the results are visualized in a pie chart on a map according to the location where they were sent. Users can specify for which location

they want to see results. In addition to pie charts on a map that provide a general overview of the distribution of Tweets, the app allows users to examine individual Tweets in more detail.

We choose to use Twitter for this app because it is a popular online platform with many active users: sixty percent of Twitter users log in through a mobile app on a daily basis. These users are more likely to use Twitter throughout the day and are more engaged with the content. They are three times more likely to use it while shopping and two times more likely to use it while commuting [2].

## 2.2 Technologies

We created a prototype for our app using HTML5, CSS3, Javascript, JQuery Mobile and PHP. The back end is programmed using PHP, the other technologies are used to design the front end. We use Google Maps API to visualize a map and Google Chart API to create the pie charts. The Twitter API is used to query Twitter. We use Sentiment140 to classify the Tweets that are retrieved after a query. We used Phonegap to create a hybrid app for Android, allowing the app to use the phone's native features.

### *HTML, CSS, Javascript and JQuery Mobile.*

We used the latest web development technologies to create a single page HTML document for our app. We chose to use JQuery mobile for the design because it allows for a faster, more customizable and more flexible development than other prototyping tools.

### *Twitter API.*

The Twitter API allows us to retrieve Tweets from Twitter based on user specified keywords and location. For our prototype, we use a free account which has a limit of retrieving a hundred Tweets per call.

### *Classification and Sentiment140.*

We use Sentiment 140 to classify the Tweets as either positive, negative or neutral. This tool was developed by Stanford computer science graduates. They use a keyword-based approach that focusses more on recall and less on precision than other tools [3]. We prefer a higher recall because Tweets do not always contain meta-information about location. However, our app has a heavy focus on location so it is important for us to

retrieve as many Tweets as possible. A lower precision is acceptable for us because we want to provide people with an general overview of other's opinions. Also, our app allows people to examine individual Tweets. This way, users can determine the precision of the classification themselves.

### *Pie charts and Google Maps API.*

Google Maps API is used to create pie charts of the retrieved Tweets [4]. Pie charts show the distribution of Tweets according to their sentiment. We chose to show pie charts because they give a compact overview of the results to users. Using other visualization techniques, for example bar charts, would clutter the view as they take more space on the screen, hiding a larger part of the map. We use the Google Maps API clustering algorithm to automatically group Tweets based on a radius around coordinates on the map [4].

## 2.3 Interface

When users open the app, they are presented with a splash screen during the loading of the app on the phone. Once loaded, people are automatically referred to the main screen. Here, they see their current location on the map as can be seen in Figure 1a.

After putting in a query, users are presented with pie charts that show opinions about the query in the current location on the map. To gather qualitative and more specific information about opinions, users can get more details about individual Tweets. This can be done in three ways: 1) tapping the pie chart, 2) zooming in or 3) tapping on the "Tweets" button in the lower right corner of the screen. The first two methods show individual Tweets on the map, as can be seen in Figure 1b.



Fig. 1a. Main screen



Fig. 1b. Zoomed in map with tweet text

The third method shows users individual Tweets in a list, as can be seen in Figure 2a. In this screen, users can filter Tweets according to their sentiment to see only the Tweets of one classification. It is also possible to see an unfiltered list.

On default, the app tries to determine the current location through the phone's gps. If this function is turned off, the app will use data from the network to approximate the current location. Users are also allowed to specify their current location manually in the screen that is shown in Figure 2b.

From both the map and the Tweet list screens, the user can query Twitter by tapping on the magnifying glass in

the top right of the screen. Users are then directed to the search screen. Here, trending topics are shown and the user can enter his own keywords in the text bar at the very top of the screen. After tapping a trending topic, or tapping the enter-key on the keyboard, the user is directed back to the previous screen. The search screen is shown in Figure 3a.

On default, users are presented with the trending topics in the vicinity of their current location. By tapping the "Change trend location" button in the top right of the screen, users can change the trend location. They can do this on different levels: worldwide, continent-wide, country-wide, city-wide or even more local. The change trend location screen is shown in Figure 3b.



Fig. 2a. Text view of the tweets



Fig. 2b. Change user's location

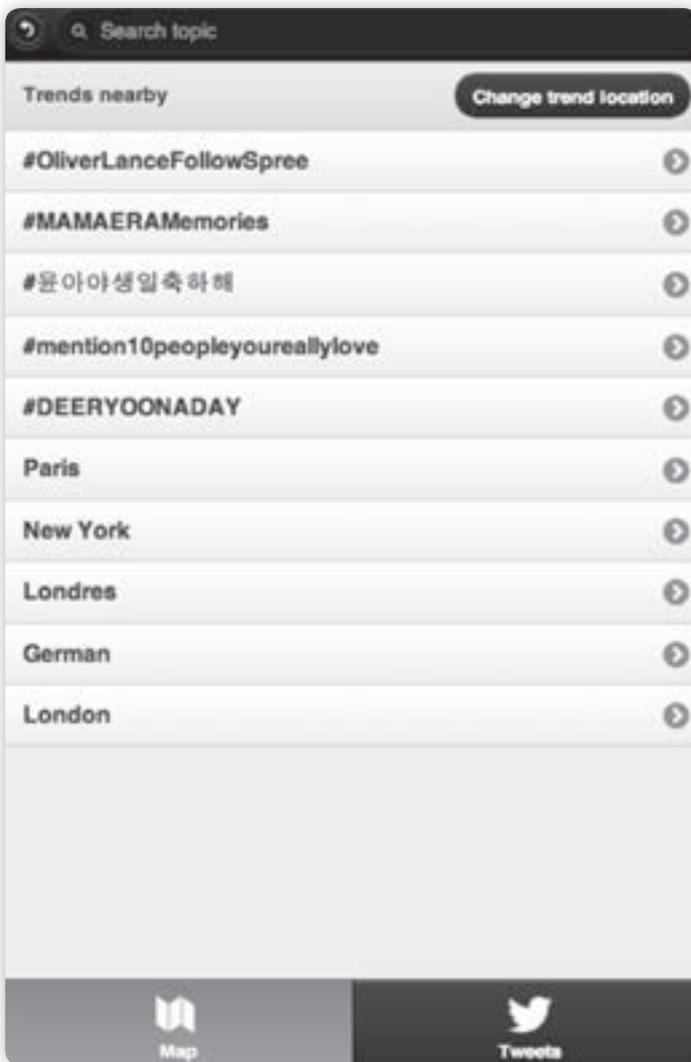


Fig. 3a. Search for topic screen

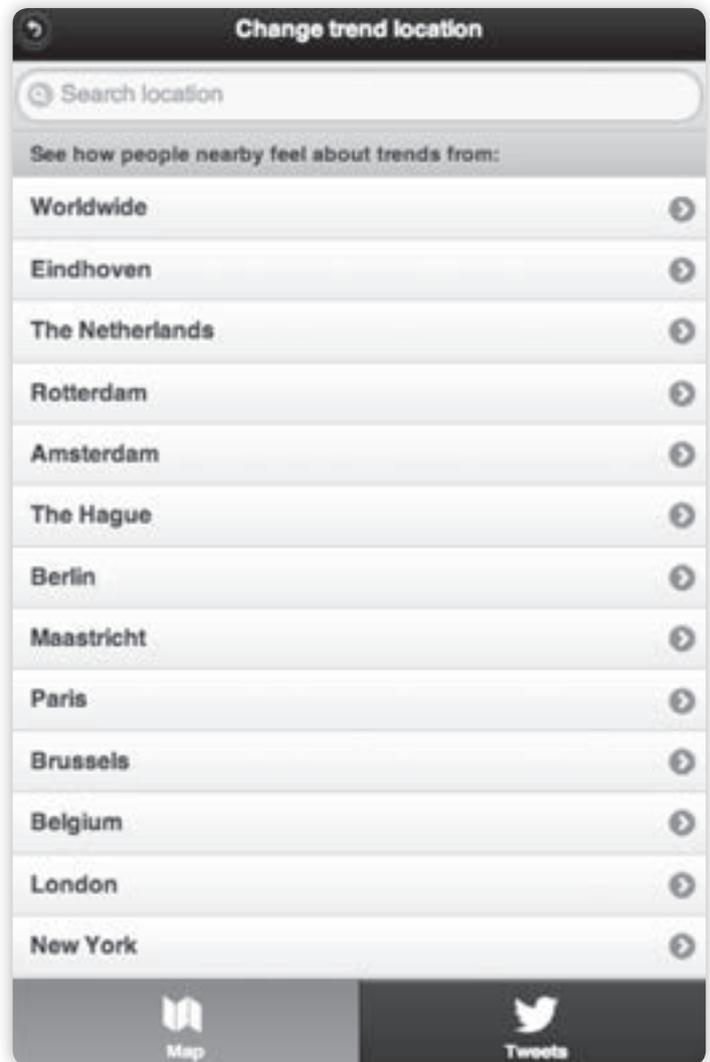


Fig. 3b. Change trend location

### 3 Prospective applications

The Sentiment Ninja application can be used in many contexts by many different target groups. In the following Subsections, we focus on the three most prospective target groups: consumers, companies and journalists. For consumers, we discuss two different contexts: exploration of the environment and buying decisions. Companies can use the app for marketing purposes and for competitor analysis. For journalists, the app is suitable in contexts where they are in the field and want to report the opinions of people on the news.

#### 3.1 Consumers

Consumers can use the app in two contexts: exploration of the environment and buying decisions. The former context applies when a user is visiting a city and wants to find out which places he should visit. The user can then find opinions about places and events in the city. Location is highly relevant in this context because the user wants to explore a specific area. Users can also query for opinions in the city without specifying a keyword to gather general opinions and discover which places are more “positive” than others.

The latter context applies when a user is in a store and needs to make a buying decision. He can then quickly find information about the product he is considering to buy. Location is relevant here because opinions might differ between countries and cultures.

### 3.2 Companies

One important goal of commercial companies is to sell their services or products to customers. Marketing is a way to gain product awareness which in return might lead to an increase in sales. When people are not buying a significant amount of products, companies need to find out why. They can use Twitter to find out how people are thinking about their product or service and examine individual Tweets to get qualitative information about the reasons of consumers not to buy the product or service. It might also be the case that a specific product or service sells well in one country but not in another. Companies can then find out why this is the case and make appropriate adjustments to their product or marketing campaign. For example, in Asia people prefer blue light while in Europe, people prefer yellow light. If light bulbs provide a blue light, European people might complain that the light is too cold. Companies can then adjust the color of the light.

The app can also be used for competitor analysis. Companies can easily see how people are feeling about a competitor brand or product. If required, they can get examine individual Tweets to find out why people are having a specific opinion. They can use this knowledge to distinguish themselves from their competitors more effectively.

### 3.3 Journalists

Journalists usually try to present facts and information objectively. Journalists are usually also interested in how the general public thinks about a specific news item. These news items are usually emerging quickly. However, it can take a lot of time to gather these opinions. It can also be difficult or dangerous to go out and talk to people in for example a war situation. With Sentiment Ninja, they can get an overview of people's opinions on the news quickly and easily. Journalists can then report general opinions, for example which candidate is in favour during presidential elections, and specific opinions, for example why a specific candidate is (im)popular. The location of these opinions can be

important. For example, with presidential elections, it might be interesting to see how people in a specific region are thinking or how people abroad are feeling compared to the local population. This is particularly interesting during potentially controversial events or in countries with a high level of governmental manipulation. The journalist can then explain the discrepancy between officially reported information and information from Twitter.

## 4 Discussion

In this Section, we discuss issues with the current design and provide possible future developments of our app.

### 4.1 Issues

In this Subsection, we discuss the following issues with the current design: language, sarcasm and ambiguity, location, and big data representation.

#### *Language.*

Currently, our app only analyzes English Tweets. This means that many possibly relevant Tweets are not recognized because they are in a different language. This problem especially arises when the user is looking for Tweets in a location where English is not the native language, although it could also occur in native countries where tourists might Tweet in their own language. Another problem here is that users might enter keywords in their own native language, not English. These issues are currently hard to resolve since most algorithms are developed especially for the English language. Also, providing a keyword in one language with the goal of searching Tweets in all languages for this topic is an issue since it is still hard to automatically translate languages.

#### *Sarcasm and ambiguity recognition.*

Although a lot of work has been done in the field of natural language processing, recognizing sarcasm and dealing with ambiguity currently still pose a problem for machine learning algorithms [5]. This can cause the classifier to annotate Tweets wrongly and poses a problem to its accuracy.

#### *Location.*

Twitter users might protect their privacy by switching off location tagging. For us, this means that possibly relevant

Tweets might not be retrieved and shown in the app, resulting in a smaller amount of available data. We try to compensate for this by using an algorithm that focusses more on retrieval than on accuracy. To allow users to find relevant Tweets, we propose to include a function in the app where users can search for a topic without specifying a location.

#### **Big data representation.**

Our app tries to solve the issue of providing an overview of big data on a small screen. We do this by providing two viewpoints separately: a general, quantitative overview in the form of pie charts and a specific, qualitative overview by showing individual Tweets. User testing should be done to examine to what extent this is an appropriate approach to visualise big data on a small screen.

#### **4.2 Future development**

One benefit of creating an app for mobile use is portability. Opinions on Twitter can be mined from any place in the world with internet access. One drawback however is the limited screen size. On a bigger screen, we could allow users to compare locations in the world that are far apart or to compare different zoom levels (for example, compare the general opinion in a country with the opinion in a city within that country). We aim to develop a desktop version in the future that allow this functionality.

Another interesting shape of our app would be to have a projection of people's opinions on different surfaces in public areas. For example, a university could show how its employees are feeling and a store might provide realtime information on opinions in the store.

We also aim to improve the technology of the app to recognize bots and propaganda in Tweets. However, automatically recognizing bots is becoming increasingly difficult. Bots getting more advanced and some, like for example Cleverbot come close to passing the Turing Test [5] which might make it hard to identify them.

Propaganda might also be an issue as some companies or governments might try to influence opinion mining results to their own benefit. Algorithms to automatically detect propaganda already exist. One existing algorithm works by looking at specific features of Tweets and is already sufficiently accurate [6].

## **5 Conclusion**

The goal of our app is to allow users to get a clear overview of opinions on Twitter based on location in a quick and easy way. We designed the app with three clear target groups in mind although it could be interesting for many more people. We did not yet have the opportunity to conduct extensive user testing to find out to what extent our app meets its goals. One next step would be to test our app. Another step is to allow users to compare different locations more easily and clearly by developing a web app that is suitable for larger screens. A next technical development would be to include algorithms to detect propaganda to prevent companies and governments from manipulating opinions on Twitter.

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# Visual-Tangram: Tangible Puzzle for Children's Intelligence Exploration

## Abstract

Tangram is an old Chinese puzzle game mainly for children intelligence exploration; it is simple and easy to make but has almost infinite combination possibilities. In recent years, however, the explosion of the development of new toys and games has pushed tangram, the puzzle of Chinese wisdom and culture, into an awkward situation. Our project sought to make the game of tangram more visual and interesting through tangible interaction, trying to inspire children playing and learning with more enthusiasm, meanwhile help this old game revive today.

## Keywords

Chinese puzzle, tangram, intelligence exploration, tangible interaction

## 1 Introduction

Tangram (or "Qiqiaoban" in Chinese) is a puzzle game consisting of seven flat shapes (called "tans"). As an open game, the objective of the puzzle is to use imagination to form a specific shape using all seven pieces, which may not overlap [1]. This gives the game another name "seven boards of skill".

Tangram originated from the Ming Dynasty for over 200 years ago. Tangram has 7 pieces, including 5 right triangles (2 large, 1 medium, 2 small), 1 square and 1 parallelogram. All these pieces can form an exact big

square, that is to say, with a squared thick paper, a knife and a ruler, anyone can make a tangram himself with ease.

Tangram has been proved effective in intelligence development. For children from 2 to 6 years old, tangram helps improving their abilities of hand-eye coordinating [2], shape cognizing, vision differentiating, visual memorizing, as well as open-mind-training and creative thinking [3]. Despite that tangram is so helpful and has been popular for over 200 years, today's tangram, together with plenty of traditional puzzle games, is facing a loss of children's attention due to various electronic products like video games, cartoons, electronic toys, which are deservedly competitive by visual appearance and rich content.

However, puzzle games, especially dissection puzzles, are still irreplaceable in helping children with hand-eye coordinating, abstract-to-visual cognizing and creative thinking. Based on this we planned to create a new visual-tangram game more suitable for children by tangible interaction [4].

## 2 Concept

Considered that children need others' help to complete cognition of abstract figures, and that children need more encouragement and achievability in learning [5], we use a computer to help recognize abstract objects

as a start, then transform into visual objects, and at last show the objects to children via multimedia e.g. animation, sound and words.

The hardware of the system includes a PC with and a web camera (see Figure 1). Operating instructions can be referred in "SCENARIO" part. The software of the system consists of 3 modules: tangram detection module, object recognition module and multimedia output module.

#### Tangram detection

Any shape detection algorithm is appropriate for identifying tangram shapes, e.g.. Here we use EmguCV-library [6]. Firstly we capture a snapshot from the web camera, scan the image to get color distribution. Since different pieces have different colors, we get angular vertexes of every piece by analyzing each pixel. With an established coordinate axis, we know the positions and rotation angles of all tangram pieces. These string numbers describe a unique tangram figure.

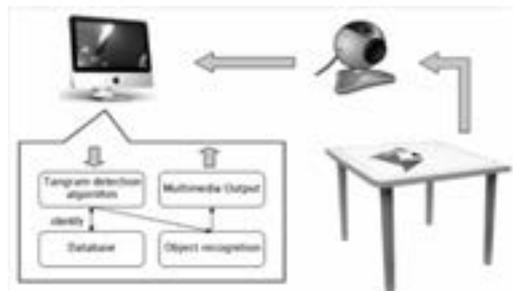


Figure 1. Architecture of visual-tangram system.

#### Object recognition

Since any figure could be described as an array of numbers, we create a property database to store the corresponding arrays. Figure 2 gives an example of how to recognize a figure of "fox". When the array of the figure shows a high similarity to the array in database, the system will judge it as a "fox". In our test,  $\sum |pr_i - pr_{0i}| * (\sum |pa_i - pa_{0i}| + \sum |rai - ra_{0i}|) < 10$  is considered as "similar".

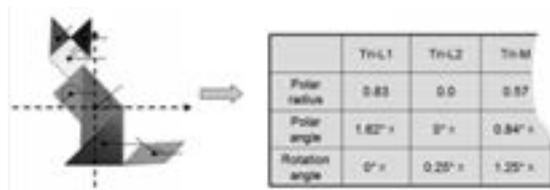


Figure 2. Any figure can be stored in database.

#### Multimedia output

When the object is identified, UI module starts to fetch object's profile, output static or dynamic animations with words and explanation voices, as vivid as possible to impress children (see Figure 3).



Figure 3. Visual-tangram system in test.

### 3 Scenario

- Lay a piece of white paper on a flat desktop, put tangram pieces on paper.
- Adjust web camera to make sure the paper and tangram in full view. Run the software.
- Play with tangram.
- After completing a work, move hands away from the figure and wait for a second.
- The screen shows an animation, telling the child what he/ she has just completed, and what's funny about this stuff.

### 4 Conclusion and future work

In our tests, 15 children aged from 2 to 6 showed great enthusiasm to visual-tangram system. They couldn't wait to try any possible combination and expect the screen show something they had expected. Compared to virtual puzzle games on PC, this tangible interaction game is more attractive and easy to operate for children. Consequently we conclude that the visual-tangram is effective in attracting children's attention and prolong their time spent on the game.

We also notice that children are highly interested in those games with feedback and interaction. In future research, we plan to develop more functions to attract children, for example, encourage them to form a short story, or even a self-directed cartoon movie with visual-tangram system.

Also we realized the insufficiency of this tangible system – the pieces detecting accuracy might be largely influenced by many factors like light white-balance and camera image quality. So we will try every possible means that might work, such as embedding RFIDs into tangram pieces and put them on a special white boxes with detect sensors inside.

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# Two design cases of social network for parents in the context of premature birth

## Abstract

We present two demonstrators of interactive and networked systems. The context of both systems is premature birth, the neonatal intensive care unit and the social situation of the parents. Both demonstrators establish a link between the physical and the digital and both take advantage of contemporary developments in social computing. The first demonstrator is called Touchee. The second demonstrator is called NICU-tree.

## Keywords

Social computing, neonatology, interaction.

## 1 Context: premature birth

When a baby is born after a pregnancy of 37 weeks or shorter it is said to be premature (Chen, Feijs, & Bambang Oetomo, 2010). Premature and ill neonates are to be treated in a special clinical environment, called the NICU (neonatal intensive care unit). In the NICU, the neonate is treated according to evidence-based therapies in which modern technology plays an important role. Continuous monitoring of health parameters is crucial for premature infants (Ahn & Kim, 2007). However, the equipment tends to separate and alienate the parents and the baby and interferes with the holistic care of the newborn (Miles & Holditch-Davis, 1997; Aagaard & Hall, 2008). Researchers at TU/e<sup>1</sup> and MMC<sup>2</sup> are contributing to improving the experiences in

the NICU, as well as more bonding between parents and their babies (Chen, Feijs, & Bambang Oetomo, 2010).

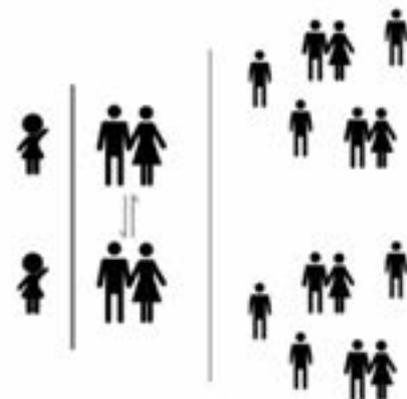


Fig. 1. Parents, peers, relatives and friends.

So far, less attention has been given to the relationship between these parents and their relatives and friends. Moreover, there is a strong need for this group of parents to exchange more experiential knowledge, next to medical knowledge. This opens up opportunities for exploration by design. In Figure 1 we show the babies, their parents and this next layer of relatives, friends and peers.

## 2 Inspiration from social computing

In many countries, there is already some form of organisation by the parents (and external parties).

<sup>1</sup> TU/e is short for Eindhoven University of Technology

<sup>2</sup> MMC is short for Máxima Medisch Centrum Veldhoven

For example, in The Netherlands, there is the VOC (Vereniging van Ouders van Couveusekinderen) with the aim to bring together the experiences of parents with premature babies. A board, bi-monthly magazines, a website, a forum and of line gatherings form the backbone. We believe it will be interesting to see what social computing could offer additionally. In Figure 2 we present a more elaborate network of relationships between various relevant stakeholders and institutions. With fast developing web technologies like SNS (Social Networking Service), information gets spread with less time and space limitations.

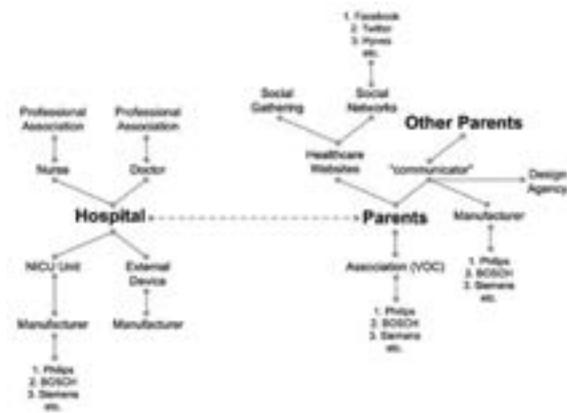


Fig. 2. Relationship between different institutions

Still, the major objective of present SNSs is to connect with people who you know already. Yet in the premature-context, the relevant group of people is more dynamic, even within a short period of time. Therefore another method of connecting (new) people should be proposed to meet this need. Pooling is a system in which people share information grouped by their (sub-) cultural values (Straub, Loch, Evaristo, Karahanna, & Strite, 2002). A similar example can be found at [www.atthepool.com](http://www.atthepool.com). Besides, in our field research, we discovered that parents do keep a diary about their babies together with any meaningful objects to associate with certain piece of memory. Thus we take keeping-diary-behaviour as an initial point to start designing within their natural flow of daily ritual.

### 3 Design concepts

Two important subjects emerged from previous investigations: 1) how to stimulate higher level of both

information and emotion exchange between parents with premature babies; 2) how to involve relatives in the recovery process by sharing proper information. We propose two different concepts, Touchee and NICU-tree.

#### 3.1 Touchee



Fig. 3. Overview of Touchee interaction components

Touchee embraces both online and of line activities. There are two major components in the system: 1) a mobile digital device in the NICU room; 2) an interactive platform in common areas in the hospital as shown on the left part in figure 3. A cloud system and a third-party collaboration of materialization are supporting in the process. Every piece of digital memory generated in the NICU room by the parents of pre-term babies is stored in the cloud, which can be accessed again with personal mobile device outside NICU room. This data (represented on a personal mobile device) together with an object from the hospital that the parents would like to combine into a holistic recollection, users can place them on the interactive platform and create a corresponding atmosphere. All the data will then be transferred to a third party materialization service where a container with meaningful shape is realized and delivered directly

to the applicant. In this manner, the combination of materialization of digital data with tangible-memorial object form a comprehensive media between the parents or even at a personal level.

While parents take efforts and spend time in designing their own gadget, there is much room for them to come across with other parents where communication happens. Furthermore, this gadget serves as a trigger at the beginning of connecting parents that a tangible object imply much more emotions than digital information. In this way, parents are bonded in a physical environment when possible, supporting by the pooling technology to group similar parents together.

### 3.2 NICU-tree

NICU-tree is a diary based socialization system designed especially for parents with premature babies. The system can be accessed in three ways: 1) a digital device in a NICU room with beamer and camera functionalities; 2) a large public display/ projection in every hospital throughout Netherlands; and 3) a personally owned portable digital device. A cloud system supports all the accessibilities. Each piece of diary and related comments has a unique QR code where users can scan and download corresponding information. The interaction structure of NICU-tree is shown as figure 4.

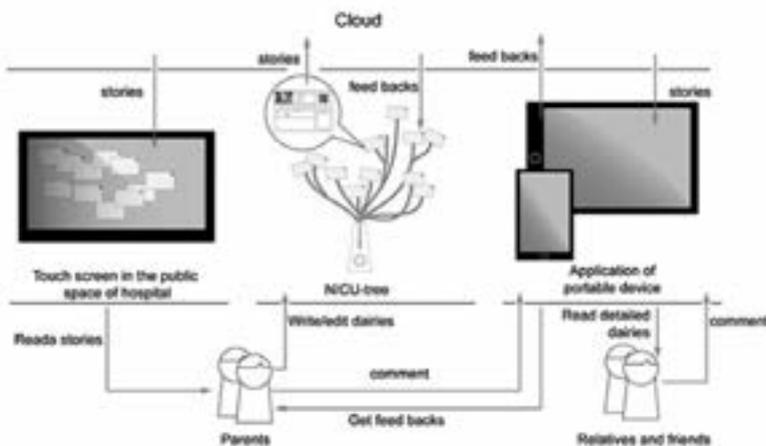


Fig. 4. Structure of NICU-tree

Different from writing a diary, parents use their mobile devices to record moments instantly and upload to the cloud. Every piece of information uploaded will be made

into a physical card that can be attached onto walls in NICU rooms. The camera of the host machine will track the location of this card and project a “branch” between itself and the card, growing into a tree gradually. At the same time, this information will be available on those public displays where other parents/ relatives can scan the QR code and interact with it, which will be reflected on the projection in the NICU room.

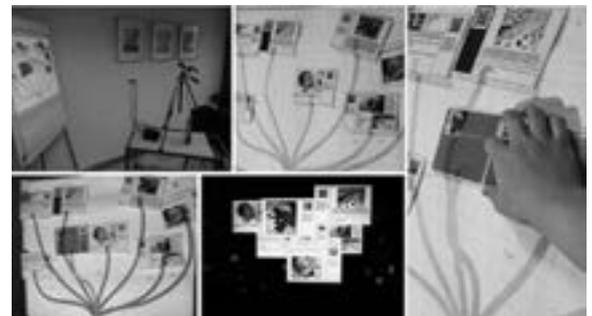


Fig. 5. Setup of NICU-tree for evaluation session

Privacy protection is also well-considered in this concept that by default, all posted diaries are private. Only after the user chooses to disclose certain piece of diary publicly then it will be shown in the public display. Besides for each of the diaries, parents can choose who to share with, that only relevant relatives or friends would receive notification. In all, privacy concern is among the top issues to tackle in this proposal.

### 4 Lessons learned

The evaluation session was taken place in MMC where ten participants from both MMC and RMH<sup>3</sup> attended. Genders were balanced to the degree possible, with two men and eight women. The babies of three of them are currently kept in the NICUs in MMC. Five of them are volunteers working in RMH, among which one mother had a pre-term baby in January 2012 who recovered well from illness. Two are experts in the field of neonatology.

After evaluating two design concepts with (potential) parents, the feedbacks confirm the potential of both systems in terms of facilitating deeper communication and interaction between parents. On the virtual level, modern technologies lower the barrier of creating, storing and sharing information, which is crucial in a stressful condition. On the tangible level, objects do

<sup>3</sup> RMH is short for Ronald McDonald Huis, Zuidoost-Brabant branch to be specific

stimulate a more profound emotional exchange that helps to build a robust relationship/network between parents. Therefore it could be meaningful to combine two systems in the next step.

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# Mobile Fetal Surveillance: A product service system design for pregnant women

## Abstract

Mobile fetal surveillance service system design is a cooperative project between DESIS Lab, Jiangnan University and Nanjing Cynovo Electronic Technology Co., Ltd. In this project, a fetus-voice meter integrated with and cloud platform is designed. It provides fetal surveillance, experts consulting and social communicating services and makes it available every time and everywhere for pregnant women and their family. To some extent, it extends the function of hospital and remits the problem resulting from unbalanced healthcare resources.

## Keywords

Fetal surveillance, Mobile healthcare, pregnant women, Product service system

## 1 Social context

China is a country without enough and balanced healthcare resource. Many of the healthcare resources are distributed in urban areas. (Chuanshu Lu, Xiuli Xie 2007) It is difficult for rural patients to see a doctor when facing health trouble with the limitation of healthcare device and service. Healthcare fee is also a challenge for those people. The function of hospital should be extended outside.

In addition, the structure of most families in China is changing into "421" family pattern which means there

are 4 grandparents, 2 parents and a child in a family. (Xun Zhang 2008) Then, the only child has to take more responsibility for the family. Reducing perinatal mortality rate and improving the quality of new-born population is an important mission of woman and child health care. Keeping pregnant woman and her fetus healthy become the focus of the whole family. Fetal surveillance is an important measure to keep pregnant woman and her fetus healthy. Electronic fetal heart rate monitoring is commonly used to assess fetal well-being as a clinical measure. (Hina Gandhi, Lucy Kean 2008). Keeping concerning the fetus healthy and monitoring vital signs periodically during ten months' pregnancy is a challenge for pregnant women under the traditional fetal surveillance in hospital because of body inconvenience. With the rapid developing of mobile technology and healthcare, echoscope will be replaced by smart phone; doctors can check the electrocardiogram for patients in different areas. It is not science fiction, but an occurring revolution on healthcare technology, M-health, combining healthcare with mobile technology, which changed healthcare service very much, gets rid of the limitation of time and space (Boroto Hwabamungu, Quentin Williams 2010). Cloud technology supported this revolution as well.

## 2 User research and the concept

After a series of research on pregnant women and their family, two important findings are highlighted. Firstly

pregnant women wanted more interaction with father-to-be. Secondly, they need more service when they measured fetus heart rate such as communicating with other pregnant women and exchange for second-hand articles. It's found that a single product can't meet the needs of pregnant women. A product service system (PSS) (N. Morelli 2003, E. Manzini & C. Vezzoli 2003) should be build to meet the comprehensive requirement of pregnant woman.

A concept of mobile fetal surveillance service system emerged. In this service system, pregnant women use a device connected with iphone to collect vital signs. Those dates were delivered to monitoring cloud-platform as well as the application. Pregnant women and their families can learn about the fetus healthy via visualization interface of the application and cloud platform. Medical care provider on pregnancy healthcare service analyzed the date from cloud platform and gave suggestions to relevant pregnant woman so that they could deal with bad situation accurately in time. At the meantime, pregnant women could share the date of vital signs to social network. A virtual community of pregnant women with the same concerning would be naturally formed. Pregnant women in this community would communicate with each other and solve problems collaboratively, spontaneously and proactively.



Fig. 1. System map of mobile fetal surveillance service

### 3 Prototyping

A set of prototypes was made out after determination of design proposal. It consists of a fetus-voice meter connected with by Bluetooth, an and a cloud platform. In this phase, fetus-voice meter could work normally,

but the relevant and cloud platform were only implemented part of features. Details of those three parts of mobile fetus Surveillance system described as follows.

#### Fetus-voice meter

Fetus-voice meter consists of body and probe for fetus heart rate. It needs to be coated with coupling when using. There is a Bluetooth button which can activate the connection to the application. In order to create a nice experience in the process of moving the probe, a special handle was designed as following picture. The date of fetus heart rate would be show in a small screen.



Fig. 2. Prototype of fetus-voice meter (component and using reference image)

#### The application

If pregnant women want to check the history of the date and learn about fluctuation of it, a is needed. This application makes date display and management possible. It also provides an access of consulting doctors and sharing dates to social network.



Fig. 3. Some interface of the application

### Cloud platform

Besides functions provided in the application, cloud platform adds some relevant services such as second-hand article exchange and pregnant women class in order to meet their extra needs we found in user research.

Mobile fetal surveillance service system was tested in some pregnant families. It is proved to be effective and have a more accurate outcome and nicer experience. Father-to-be and pregnant women have a good interaction when using it. Something insufficient were also exposed. Firstly, the size of fetus-voice meter probe was too big so that it was easy to soil belly of pregnant women when coated coupling. Secondly, a pregnant woman can't use body of fetus-voice meter and at the same time by herself. Without support of her husband, it was not convenient to use it.



Fig. 4. Scenes of users testing

### 4 Discussion and conclusions

This project builds a product service system for pregnant women and their families, the first prototype works within expectation. there are a lot of work to be done at next phase including product development and the whole system optimizing. From concept, prototyping to testing, what we learned are in follows:

- A single product can't meet the comprehensive requirement of users in many cases. A systematic

perspective for designers is employed. In this project, a product service system is designed. It consists of a mobile device for fetus heart rate measurement, an and a network for relevant requirement.

- Products are able to help to create a harmonious relationship of humans. The fetus-voice meter in this project makes father-to-be and pregnant women join forces and enjoy a good time of communicating with their fetus. It is also important to point out that designer should control their utility they put on products. Influencing but not forcing users is a proper way to create a harmonious system.
- Technology stimulates innovation. Mobile technology combined with healthcare industry increases many possibilities for fetal surveillance revolutionarily. Identifying opportunity of technology is very important in the new product and service development.

### 5 Acknowledgement

We thank to all colleagues and users who give supports during the project and it's partly supported by Ministry of Education Humanities and Social Science Youth Fund (11YJC760018).

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# Vibe-ing: Designing a smart textile care tool for the treatment of osteoporosis

## Abstract

Vibe-ing is a care tool in the form of a garment, which invites the body to feel, move, and heal through vibration therapy. The merino wool garment contains knitted pockets, equipped with electronic circuit boards that enable the garment to sense touch and vibrate specific pressure points on the body. With this design we aim to inform a multi-disciplinary audience about the opportunities of integrating textile and vibration for healthcare applications. We show how new manufacturing can lead to new possibilities in garment design and the integration of electronic components. With an example of dynamic behavior we demonstrate how the vibration therapy of the garment can be tailored to individual treatment needs. This design serves as a start. We plan to further investigate the effects of vibration therapy combined with textile design and electronics for the treatment of osteoporosis.

## Keywords

Smart textiles, wellbeing, customization, product behavior.

## 1 Introduction

Vibration has three positive therapeutic applications: (a) for the improvement of bone density and muscle strength [1]; (b) for the attenuation of delayed-onset muscle soreness [2]; and (c) for an increase of the speed of the blood flow through the body [3]. Vibe-ing is a care tool in the form of a garment, which invites

the body to feel, move, and heal through vibration therapy. The aim of this design is to contribute to the treatment of osteoporosis, particularly for women who are most at risk of developing osteoporosis in the post-menopause period [1, 3] and therefore supporting the need for their wellbeing. The textile from which Vibe-ing was constructed has been produced using a fully-fashioned knitting machine. This technique allowed us to create digitally designed, pre-shaped pieces for the garment. The textile contains pockets in which circuit boards with sensors (touch sensors) and actuators (vibration motors) can be placed (shown in Figure 1). Throughout the textile power and communication lines are integrated that connect the pockets with each other. This modular system enabled us to program the exact areas and the way of stimulation on the body depending on the specific person's need for rehabilitation and healing.

By developing this prototype we aim to trigger a multi-disciplinary audience to consider the opportunities of integrating textile and vibration for healthcare applications. We hope to bridge the disciplines of fashion, technology and healthcare. Further, we highlight the possibilities of integrating textile and electronics using modern manufacturing techniques. Finally, we will show how a body-worn decentralized network of vibration and touch modules enabled us to add a dynamic behavior to the garment, tailored to the needs of the person wearing Vibe-ing.



Fig. 1. Left: front of Vibe-ing with two rows of pockets. The white circles visualize the vibration of the modules. Right: back, with the pockets containing the vibration and touch modules on the spine and shoulders. The silver lines are the connection lines between pockets

## 2 Textile and technology for healthcare

Relating to the integration of textile and technology for osteoporosis applications there are some design choices we would like to emphasize. These design choices show the challenges within the different levels of the design process. We choose for merino wool as textile fiber because of a number of attributes and beneficial properties. These properties include a resistance of chemicals and dirt, absorbency, insulating capabilities, resilience, positive tactility [4] and versatility [5]. For the textile design we used two layered knitting and felting techniques to produce a textile with a voluminous shape, soft and bulky surface. This surface invites the wearer to stroke and touch the fabric and the body. For the integration of technology we choose for vibration actuators that are integrated in the textile pockets. This combination enables the application to have a healing effect on the muscle density of the people wearing the

garment. In the garment design we placed the pockets to align with critical pressure points on the body (Figure 1 shows the specific placement of the modules on the body of the wearer). For example, the shoulder area is a difficult location to perform surgery when fractured. Noninvasive treatment, such as vibration on this location could increase the bone density and relief shoulder pain. The lumbar region on the back is often associated with a sedentary lifestyle, and a source of chronic pain for many older people.

Vibration could relieve the pain by increasing the blood flow in this specific area [1]. By rotating the garment (back to the front, top to the bottom) we can further stimulate pressure points on the front of the body. This can offer stimulation of the hips and the ribs. These two areas are often affected by decreasing bone density in the post-menopause period [1, 3]. Simultaneously, flexibility in wearing the garment in different ways enables different treatments with the same garment, limiting the amount of textile, electronics and energy. In conclusion, these aspects – merino wool properties, the knitted soft surface and vibration actuators embedded in the pockets in the garment – could contribute to the feeling of physical-emotional comfort as a noninvasive therapeutic treatment of osteoporosis.

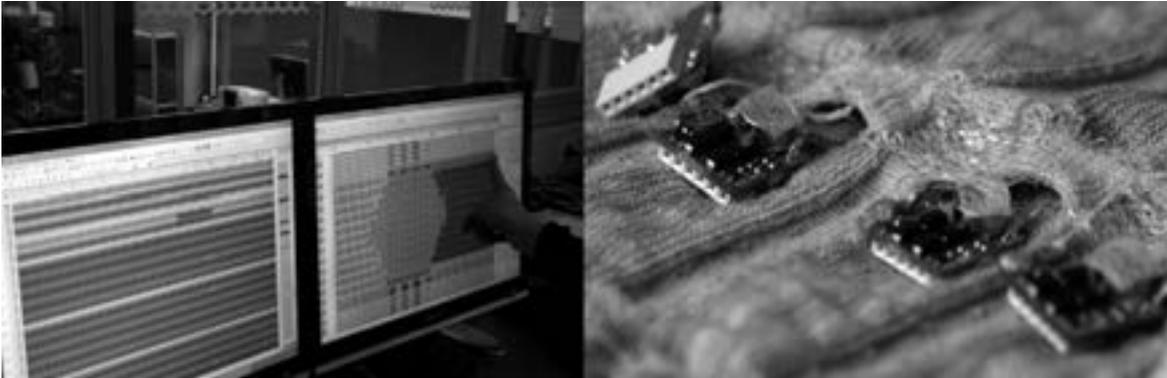


Fig. 2. Left: the computer interface to design the pockets. Right: the bottom of the pockets, showing the touch sensitive fabric, the connection lines and the electronic modules

### 3 New manufacturing possibilities

Besides showing the potential for healthcare, the design of Vibe-ing is also an exploration of the possibilities to bring the manufacturing of textile and digital design tools closer to each other. Modern manufacturing techniques, such as fully-fashioned knitting, make it possible to produce a garment without the need of additional cutting and sewing (the left picture in Figure 2 shows the digital tools used to design complex textile complete garments). These techniques will enable designers to produce in smaller quantities, customized to the users needs, shape of the body, and aesthetic preferences, thus reducing waste compared to traditional mass production of garments [6]. At the same time, this allows for more complex structures that make it possible to integrate technological elements into textiles. This perspective expands the design discourse in terms of how garment design is more integrated with body consciousness, which links to a sense of physical wellbeing. We will illustrate these new possibilities with examples from Vibe-ing. During the design process the merino wool was knitted using a jacquard pattern to create a bulky structure after being felted. The garment can be customized to different body shapes, while the placement of the vibration modules can be modified to the needs of the individual user. The pockets in the garment contain specially developed modular electronic circuit boards with actuators and sensors on it (the modules are shown on the right picture in Figure 2). Connected by power and communication lines, these modules provide the therapeutic vibration. The knitted construction of the pockets consists of a combination of different yarns. In the bottom of the pocket a mix of a

soft conductive yarn and an elastic yarn to function as a stretchable touch sensitive surface (showed on the right picture in Figure 2). Because of the conductive yarns it becomes possible to measure the body capacitance of the skin touching the fabric, creating a basic touch sensor. The copper yarns knitted in the textile, provide the power and communication throughout the garment, while in the pocket they run freely to make them accessible for connecting to the circuit board.

### 4 Behavior of the garment

With this design we would like to show the possibilities of a body worn network of sensors and actuators integrated in the garment. We see more and more examples of intelligent systems consisting of different nodes, for example in living rooms [7], lighting systems [8] and textile applications [9]. These make it possible to extend the functionality of separate products, and can transform previously static products into products with a dynamic behavior. In Vibe-ing we distributed multiple modules in the garment, corresponding to different locations on the body. With this configuration it became possible to program the exact areas and form of stimulation on the body, depending on the specific person's need for care, rehabilitation, and healing. The modules in the garment are programmable using the Arduino platform, enabling designers to quickly adapt the functionality and behavior of the garment. As demonstration of this platform we designed an initial behavior for the garment that is based on a ripple pattern (similar to a wave in the water or sound travelling through air). A vibration would start in the pocket which was touched by the person wearing the garment. Then, slowly the vibration would transfer to the surrounding pockets, until it faded away after a certain period (this dynamic movement of vibration is visualized by the white circles on the left picture in Figure 1).

## 5 Further research

The work we presented in this short paper is still preliminary and serves as a trigger to open further research. The garment has been designed as a platform to explore different behaviors of the vibration motors. The implemented “ripple behavior” is one of the possibilities but has not yet been verified for the treatment of osteoporosis. Our assumption is that the behavior of the garment could engage the user in the treatment process. For example, by guiding the touch of the person with the vibration motors to specific pressure points, or by gently reminding the person to stimulate the pressure points during long inactivity. As a next step it will be necessary to design these different behaviors in collaboration with practitioners and end-users, and to validate these behaviors with user tests. The placement of the pockets is based on the specific pressure points and has been carefully selected. By further discussing this placement with experts, and conducting user studies with the prototype we hope to be able to validate the placement. To treat osteoporosis effectively we will further investigate existing scientific and medical implementations to find out more about the amplitude and frequency characteristics of the mechanical stimulation. Thereafter, it will be necessary to monitor this frequency and let the vibration modules adapt to the right frequency in relation to the location of the pocket on the body. Because of the fully-fashioned manufacturing technique it becomes possible to customize the garment to the preferences of an individual. This opens up new design possibilities and new business models that can be explored. To conclude, in further research it will be crucial to collaborate with medical experts to evaluate our application of vibration therapy and extend it further based on knowledge in the medical field. To explore the possibilities of customization and the design of a personal care tool it will be necessary to involve end-users and manufacturing partners to make sure the garments fits the individual preferences and body shape and measurements of the person.

## 6 Acknowledgements

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# Social Blobs, an Interactive Art Installation in an Urban Public Space

## Abstract

In recent years, with the rapid development of technology and culture, digital media art has arrived into view. Taking "Social Blobs" of "Interactive Patina of Culture" as an example, this paper begins from the application of interactive art installations of digital media arts to urban public space, and introduce how to merge interactive art installations with public space and the historical and cultural background of public space.

## Keywords

Projection Mapping, Interactive Art Installation, Interactive Patina of Culture

## 1. Introduction

Since 21th century, the popularity of computer technology has changed traditional art forms in multiple ways. At the right historical moment, digital arts including interactive art installations appeared. Representing new audio-visual experience in both expression forms and interaction forms [1], interactive art installations cover various subjects including design arts, computer graphic techniques, media hardware materials, web of things, etc., even related to biology, music, and physics. Hence, in order to make complete design and creation, it requires that the creator had multi-discipline background knowledge. In recent years, due to the efforts of artists, designers and architects, there are numbers of interactive art installations

used in global significant festivals and exhibitions like "ParticipArt[2]", "KALI[3]" and "Tate (an art museum in UK)". In previous reported works, we found that technology innovation is focused more. However, the deeper cultural connotation of the artworks is rarely concerned. It is a challenge for us to fuse culture and interactive art installation.

Unlike traditional arts, an interactive art installation, which is consisted of installation and artistic expression, is live art controlled by computers. In our design Social Blobs concerning the subject Interactive Patina of Culture[4], we use installation to acquire user's action, and then influence user's action through artistic expression method. The philosophy of the unity of human and computer is merged into the interaction of the installation, user's action is acquired by program, the gathered data are artistically displayed after being calculated, and the participants may receive the most direct experience through projection techniques, therefore, the fusion impact and exploration of arts, culture and techniques are really achieved.

## 2. Design of Social Blobs

The theme of this time's workshop is "Interactive Patina of Culture", of which "culture" is mostly highlighted, meaning culture is the soul in the interactive design of urban public space, if the art works do not contain culture, they will lack ideological connotation. And the design will be worthless, and feeble even though it exist

in the city. While the word patina means continuousness and accumulation, that is, each participant may leave relevant “footprint” in the works. It is the theme’s key point as well as difficult point how to rationally and perfectly merge “patina” and “culture” into interactive installation design.

Based on the theme of this workshop, designers designed a set of interactive art installation in public space for Taicang-the holding location of this workshop. As the starting point of Zheng He’s seven expeditions to the western seas[5], Taicang owns plenty of culture accumulation, and is a natural bridge for Sino-foreign culture communication. The participants of this workshop are made up of teachers and students from Jiangnan University and those from Eindhoven University of Technology, during the communication, the creators found enormous cultural differences between China and Holland. For example, when going out, Chinese people enjoy walking together with several friend, and the distance between them may simply equal that of their personal relationship; while in Holland, the distance between people cannot just represent their personal relationship. Based on the extension of this case, the creators gain lots of design inspiration. As a design case of urban public space, the importance of interactive installation’s site selection is never less than its content design. Taicang has been a culture cradle since the ancient times, all sorts of talents gathered here, so it has a solid culture foundation and forms its own features, and all these constitute unique Loudong Culture, leaving age-old and outstanding culture treasures for people today, of which Zheng He’s seven expeditions to the western seas is the most dazzling one. Located in the center of traditional Taicang urban business circle, and taking Zheng He’s seven expeditions to the western seas as the whole square’s cultural background, Nanyang (means ocean) Square

is a shopping plaza which has the largest area, the most functions, and the most complete industry planning, therefore, it becomes the first choice for this case. During the early stage of interactive installation design, due to Nanyang Square’s unique position, the designers make an in-depth study on the crowd in the square, and classify them into three categories according to their behavior characteristics, which are highlighted with three colors, namely, red, orange, and blue, respectively. Blue is a kind of cool tone, standing for loneliness, so the blue color is used to stand for a lonely person walking in the square. Both orange and red are warm tone, standing for warmth and friendship, of which red is more powerful and used to stand for small groups that own leadership, while orange stands for ordinary small groups. Every small group is part of the society, so the creators also use the concept of cells to stand for every group. For the orange group, the size of relevant cells is determined by the cohesion among them. In China, unity means power, so the smaller the distance between the individuals is, the larger the cell will be, otherwise, it will be smaller. For the red group, Chinese leaders usually walk ahead of the group, and the number of the population following the leaders determines the size of the red cell, and also stands for the leader’s leadership skills.

As the largest comprehensive square, Nanyang Square has a round platform and a neat building facade (see Fig. 1), Projection Mapping technology is adopted to synchronically cast the crowd features on the round platform and building facade. To enable the interactive installation to possess more universal application, designers further abstract the cells into formal circles, but reserve their fusible features. When participants walk on the round platform, circles that have the same features with the crowd will follow the crowd under their feet, and the circle features may vary in color, size, and shape with the changes of the participants’ distance and relationship. When two crowds of participants meet or part with each other, their feature circles may merge or part with others, the feature circles’ colors may also change accordingly. The course of fusion and separation may be the most simply and concretely reflect subtle changes of the relationship among the participants. Finally, when the participants walk out of the round platform, their relevant feature circles will continuously accumulate on the building facade, new feature circles will cover old ones, and the long-period feature circles



Fig. 1. Prototype of Social Blobs and night scene of Nanyang Square

may vanish with the accumulation of time, which is the so-called patina of culture.

### 3. Implementation techniques of Social Blobs

The Social Blobs interactive installation (see Fig. 2) is made up of three parts, namely, data gathering, data processing, and graphic output. In data gathering, sensors are used to obtain the participants' position data, Arduino[6] may obtain data from the sensors through simulation electric signals, pack and send to the computer, after the Processing[7] in the computer obtains the data, it will sort and process the participants and achieve abstract graphics, then these graphics are presented to the participants by projector by means of Projection Mapping.

The current popular Arduino development board and Processing programming language are adopted in combination (see Fig. 3) for the main control part of this interactive installation. Arduino is a handy, convenient and exible open source electronics prototyping platform, including hardwares and softwares (Arduino IDE). It is widely used by artists, designers and fans. Arduino may sense the environment through all sorts of sensors, feedback and in uence the environment by controlling lighting, motors, and other devices. The micro control units on the electronic board may participate program response, and connect with the interactive platform by using Arduino programming language.

### 4. Discussion

In order to make our work Social Blobs has a strong public participation, the most instinctive behavior of human is adopted. The trace left on the square by participant is displayed as an abstract visual social interaction. Making participants as the center of the whole interactive installation, ticking out deliberately arti cial creation, this design creates abstract art patterns of interpersonal relationship which merge into cultural fundamental embodiment with the most natural and simple modes of participants random wandering. This mode that allows users to design may make the whole interactive installation full of interest and unpredictability, and let urban public space more vivid, full of humanity and cultural connotation. As the achievement achieved by the Sino-Holland Workshop, Social Blobs has won spectators praises and panel judges' consistent af rmat ion.

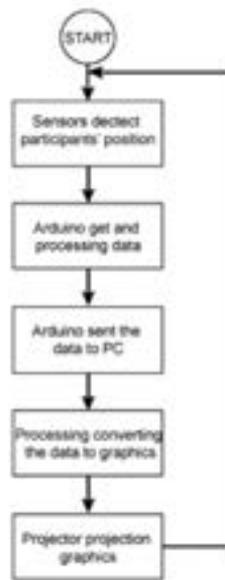


Fig. 2. Flow chart of Social Blobs

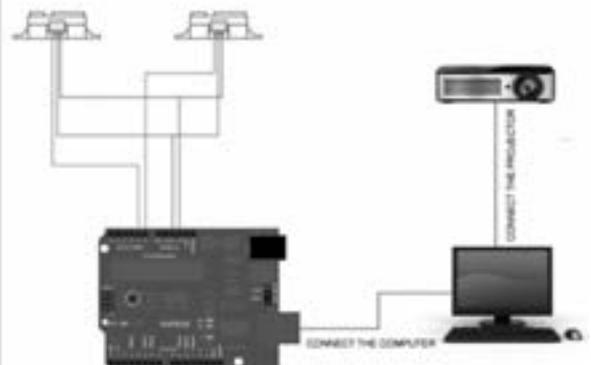


Fig. 3. Working principle diagram of Social Blobs

With the development of social culture and information technology, the new art form that uses of interactive art installations in public spaces will be gradually popularized and commonized. The workshop of "Interactive Patina of Culture" is an active exploration where interactive installation, public device, and historical and cultural background of the public space are merged together. However, as a kind of art form, interactive art installations should not always pursue technical innovation, but create distinguished design works by craftily using reasonable technical means from the perspective of cultural connotation and meaning.

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# Makin' Cake and the Meaning in Games

## **Abstract**

Why is it that players can do the most extraordinary (e.g. violent or physical) acts in games without hesitation, reluctance or doubt? What do objects and actions in games mean? This article introduces the notion of the opacity of play: Play is opaque towards non-players, its meanings are not transparent. The article also offers an explanation how people deal with this, that is, why spectators struggle and players easily cope with it. The interactive installation Makin' Cake demonstrates the issue by providing an immediate and provocative experience to players and spectators. It appears that play is not dependent on or even interested in the subject matter it plays with. Players most naturally understand and know that their actions do not mean anything. In this respect, play acts like a fun-house mirror into Wonderland, reflecting ordinary life but giving it its own twist, path, and, finally, meaning, free and independent from the everyday world.

## **Keywords**

Installation, play, game, media, transparency, meaning, swearing, cake, baking, 1950.

## **1. Introduction**

Why is it that players can do the most extraordinary (e.g. violent or physical) acts in games without hesitation, reluctance or doubt? There are many games in which

players are asked to perform quite dodgy things which are essential to the game play, and without which the games do not proceed. Stealing an object from each other (as in many ball games), physically assaulting, potentially hurting and injuring each other (as in many contact sports), or taking off each other's people (as in Chess) are examples from traditional games. In digital games, digging up a human bone from a graveyard in *Monkey Island 2* (1991) appears relatively harmless compared to activities in some of today's games (e.g. the (optional) massacre of unarmed civilians at an airport in *Call of Duty: Modern Warfare 2* (2009) [13] and the killing of a large portion of the population of the city of Stratholme in *Warcraft 3: Reign of Chaos* (2002) [33]). While occasionally there is some discussion (e.g. on the baptism sequence in *Bioshock Infinite* (2013) [22, 7, 10]), it appears not to be a major problem for the majority of players to carry out these activities [cf. 34], neither in traditional games nor in digital games.

There appear to be several possibilities to explain this. For instance, it can be argued that experienced players of popular games are desensitised zombies or social freaks who are unaware and ignorant of their actions; or that they have become computer-savvy media geeks who are able to decode games from an analytical distance without being bothered by their content. Here, a conceptual explanation is offered that argues that players most naturally understand and know perfectly well what their actions

in games mean and how they relate to everyday life. There appear to be at least three aspects to the question of meaning in games: What do objects and actions in games mean? How are these meanings constructed? By and for whom? The article focuses on the first one; the interactive installation *Makin' Cake* demonstrates the issue of meaning of play activities within and without play by providing an immediate and provocative experience to players and spectators.

## 2. The Makin' Cake Installation

The *Makin' Cake* installation (Figures 1-2) is a skill-based competitive single player game with a twist. Players type-in 1950's cake recipes as fast as they can and get points for every word. The twist are extra points for swearing, but there is a time limit, and players might lose the game if they swear too much.



Fig. 1. Title screen, main menu, in-game (screen shots)

To play the game, players select a recipe from the main menu. Each recipe is divided into nine steps. The ingredients to be used and the actions to be performed

in each step are displayed at the top of the screen/projection. Players type in what needs to be done, e.g. 'Add flour'. They then press return/enter to go to the next line and the next step. In each step all ingredients and actions (up to three) have to be typed-in. For each line players receive a score calculated from the number and length of the words they entered. Swear words produce roughly ten times as many points as non-swear words. Words that are used repeatedly give less points each time until they do not give any points at all. The exact points scoring algorithm is purposely not made transparent to players.

In the game, there are nine different levels or recipes. The recipes are based on actual vintage cake recipes from the 1940s, 50 and 60s [21, 3, 5]. They have different time limits. Recipe 1 (One Egg Cake), for instance, has a time limit of 90 seconds. When players succeed in typing-in a complete recipe inside the time limit, they are informed if their score was high enough for them to be invited to join the champions' hall of fame. In this case, they can enter their name and have their picture taken. The photo high score list adds an interesting layer to the game, i.e. how and if players stand by their recipes full of swearing; also, players can play off the props available in the setup (e.g. large spoon, chef's jacket, apron, hat). The top recipes are displayed while nobody is playing, revealing a peculiar mix of baking instructions and shocking language.

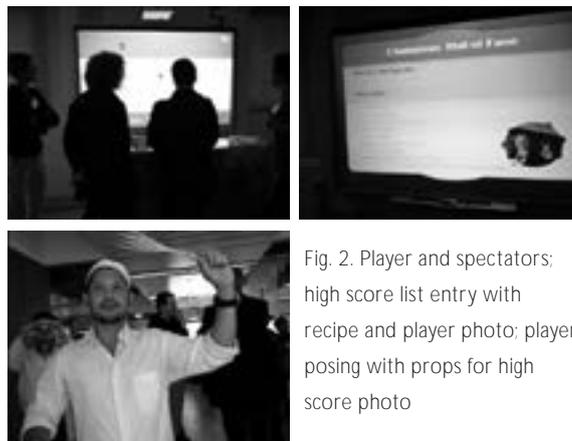


Fig. 2. Player and spectators; high score list entry with recipe and player photo; player posing with props for high score photo

The installation demonstrates a conflict between play and the everyday world. Players are provoked by a 'moment of self-confrontation'. The game confronts people and makes people confront 'an authentic but disquieting side of [themselves]' [19]. Participants

have to juggle playing the game and performing for spectators, explaining and potentially justifying their actions. Spectators are challenged to enter the game and become players; they switch from the everyday world to play and back. The setup as an installation (a 1950's kitchen), where playing the game means also performing for an audience, invites critical reflection and discussion.

### 3. Conceptual Distinction of Play and non-play

For Huizinga [9] and Scheuerl [25], play is conceptually clearly divided from everyday life. Among the characteristics they use to describe play, the freedom and the secludedness or limitedness of play appear to be the most relevant for the question at hand.

Huizinga's notion of the magic circle describes a place beyond ordinary life. 'In the play-state you experience a protective frame which stands between you and the 'real' world and its problems, creating an enchanted zone in which, in the end, you are confident that no harm can come.' [1 qtd. in 26] The boundary of play which is established in the heads of the players can coincide with e.g. lines on the ground or special uniforms, or rather, is articulated or realized through them. 'Although this frame is psychological, interestingly it often has a perceptible physical representation: the proscenium arch of the theater, the railings around the park, the boundary line on the cricked pitch, and so on. But such a frame may also be abstract, such as the rules governing the game being played.' [Ibid.]

### 4. Play is self-referential

Play is only interested in itself. There are many examples in which e.g. issues, problems or differences players have outside of play do not translate into play. On the possibility of hiring drummer Matt Sorum into Guns n' Roses, Slash recalls: 'The pay was good and there were no rules, except for one: all you had to do was play well.' [29] Hot rod and motorbike customizer Cole Foster states that he does not have any tattoos, no mobile phone and no iPod, and that he did cry when Bambi was shot – but in the end it was only relevant what he builds [11].

The meanings play creates by and in itself massively outweigh their import from the outside. Willke [31, my transl.] describes the autopoietic quality of human – social or personal – systems and claims that they

need to be understood as 'closed systems which create and maintain themselves, that is, they produce their specific dynamics not only as a reaction to input from its surroundings, but primarily through their self-organisation'. [23] Maturana [16 qtd. in 20] terms this a 'closed causal circular process'. 'It is this particular formal structure that Maturana and Varela [17] label 'autopoiesis' (or self-forming) [...]'. [20] Arguably this applies to play even stronger than to other media.

### 5. Import of Objects and Actions into Play

Play uses activities and objects from ordinary life and pulls them into play. The everyday meaning something has might serve as a starting point for people to understand what something means in play, but this meaning is only a weak indication of the meaning something has in play. 'The question is, [...] which is to be master – that's all.' [4] Play can assign meanings freely and arbitrarily, regardless of what things mean elsewhere. 'Game actions refer to actions in the real world, but because they are taking place in a game, they are simultaneously quite separate and distinct from the real world actions they reference.' [26] Even more: 'When we play a game, we are doing more than just shuffling signs drawn from the domain of the real world; instead, we are shifting to another domain of meaning entirely.' [Ibid.] Retter [23] states that the play-external world only offers material to play, and that play transforms objects when it moves them into play.

### 6. The Play Material

Whether the material that is played with is imported into play, especially manufactured for play or used exclusively in play, it is only played-with. It is not the content in itself which is interesting to play. Play is not about soccer balls, chess pieces, playing cards, toy trucks, tennis rackets, or princesses. How all-important the material might be or become to players, the play material is not interesting in itself, but only enables play, and is, essentially, exchangeable.

The activities of play are often quite ordinary, tedious or trivial. While the actions and objects of play might appear similar to actions and objects of everyday life, they lose essential parts of their meaning; play takes away the need, the necessity, etc. They enter into a new and different space in which they are assigned new meanings independent of the ordinary world, by the

players, according to the possibilities they offer to play. Their original meanings might still vaguely hover in the background, but they are not relevant to play. Playing on American tanks as after the second Gulf war in Iraq loses its attraction quite quickly when play takes over from ordinary life. NBA player Dennis Rodman [24] calls the basketball 'the fucking thing', and echoes McLuhan [18] who says that 'ostensible program content is a lulling distraction needed to enable the structural form to get through the barriers of conscious attention'. Play's content is only a tangible articulation of an ideal space, and is called 'material props' by Dunne and Raby [6], and 'texture' by Aarseth.

## 7. Creating Reality

It is not the reflection, the learning or the gain of insight about reality that drives play, but the creation of reality. Play is not an abstraction of ordinary life or a duplicate or a copy of the everyday world. It applies what Manovich [14] says of computer graphics: 'Synthetic computer-generated image is not an inferior representation of our reality, but a realistic representation of a different reality.' Play is not ordinary life, but real nonetheless. Who wants to say what it real and what is not? Following Luhmann, '[b]oth non-play and play are 'realities,' because they are products of a distinction, a difference that makes a difference.' [30] In play, players encounter a fully-valid reality. Play is made up of real actions in unreal worlds. Play is neither a *schein* reality or an *ersatz* reality; it is not defined or legitimized through references into an external reality, very similar to art which, according to Heidegger, 'does not depict or represent the world. It creates a world of its own.' [12; cf. 8]

## 8. Medial Bleed

Although play does not aim to change the world, the bleed of effects from play into the play-external world is often at least tolerated by players – in many cases this by-product of play actually appears to be quite welcome (for instance, a reputation or fame). Medial overflow into other media or into everyday life is not limited to play, and a well-known phenomenon: 'Hollywood is a town of fabulators. The people who dwell there create fictions for a living, fictions that refuse tidily to confine themselves to the screen, but spill over into the daily lives of the men and women who regard themselves as stars in the movies of their own lives.' [2] Also,

meanings trickle from ordinary life into play. Apparently, the well-known British train robbers Biggs, Edwards, Goody, Reynolds, Wilson and Wheeler, who took between 2.3 and 2.6 million pounds from a Royal Mail train in August 1963, played Monopoly with real money in their farmhouse hideout after the heist [15].

## 9. Conclusion

Play is not dependent on or even interested in the subject matter it plays with. While there is an interplay, and play material is important to play, it is only played-with. It does not mean anything, that is, beyond play. Likewise, players' actions do not mean anything. In this respect, play acts like a fun-house mirror into Wonderland, reflecting ordinary life but giving it its own twist, path, and, finally, meaning, free and independent from the everyday world. The notion of the opacity of play is proposed to describe this phenomenon.

Players assign meanings to actions and objects which only depend on the meanings they have or gain in play. Other media may reference ordinary life to a stronger degree, or rather, at all. Play is opaque with regard to meaning, and games are strongly autopoietic. Players accept all kinds of play actions, because they are empty [28]. Every child who plays, 'knows that it plays' [9] and is aware that it is 'only pretending' [9; cf. 26, 27]. Players 'are different and do things differently' [9], and most naturally step out of the systems of meaning that surround them in the everyday world, without being social freaks or media experts. Players understand play, spectators do not, because they have different perspectives on what is happening, and different ways to participate.

This situation is the potential the *Makin' Cake* installation plays off: If the meaning of a medial text is always open [32] and is to be determined in an heterogeneous manner by the people involved, and cannot be predicted, there is potential for conflict. The installation goes a step further to create a confrontational situation in which the restraints, customs, laws, rules, etc. of ordinary life are juxtaposed with the freedom, emptiness and meaninglessness of play. Players and spectators have to face the conflicts that appear between them; but there are also conflicts to face for the same person having been a spectator before and being a player now. *Makin' Cake* emphasises

this change of perspective, this step into and out of play; it confronts players with their own joyful, unreflective, direct and immediate experience, and provokes people in their role as spectators.

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# Interactive Art Installation for Creating Sense of Belonging in a Working Environment

## **Abstract**

Recently we have witnessed increasing interest in dynamic art forms in public areas using interactive art installations. We find that funny games are mostly used as the form of these design works, which often results in a mismatch of artifacts and culture.

This paper describes the design process of an interactive installation in the working environment. This installation is designed to create sense of belonging for employees in the Taicang industrial zone based on their needs and local culture. We attempt to find out the elements which can influence the form of interactive art installation through this process to remove the "mismatch".

## **Keywords**

Interaction design, working environment, interactive installation.

## **1 Introduction**

For centuries, design is always about form and function. But where is the "function" when it comes to interaction design. It is a bit different from many other kinds of design such as industrial design. After the process of using an industrial product we can say this work of design is useful. However, can we say an interaction device is very useful when we have just experienced it?

Maybe not. Interaction design is that kind of effort which combines process with emotion rather than just colorful digital animation or games for fun. How can we say an interaction device is useful and how can designers make it useful? We want to find the answer from this workshop by exploring the concept of interactive patina of culture. Culture is one of the factors which we believe to make the process of interaction unique and useful. The traditional dynamic arts have much to offer and it is time to explore how the theories and techniques from drama, film and opera could contribute to interaction design [1].

### **1.1 Taicang industrial zone**

We start the project from the case of the Taicang industrial zone (Fig 1). Newly developed hi-tech zone like the Taicang industrial zone is very typical for this project. It is a hi-tech zone 40 kilometers away from the center of Shanghai. The Taicang industrial zone which is set up by the Taicang government is built to attract hi-tech companies, investors and talents to transform the structure of local economy, creating more working opportunities. There are a lot of companies in this hi-tech zone now including scientific institute, media companies and communication enterprise. Most of them are newly set up as branches or department offices. The Taicang industrial zone is still under construction, the second wave of establishment is about to finish.



Fig. 1. The Taicang industrial zone

## 1.2 Stakeholders

What we want to achieve is to put valuable emotion into interactive physical interface which we believe is “useful” and this emotion may come from local culture. Although employees in this working environment are the group we want to design for we hope it is not only useful for employees but other stakeholders. The usability may be different to different stakeholders.

There are 3 main stakeholders groups: Taicang government, companies which has set its department office or decide to invest in the Taicang industrial zone and employees following by.

The Taicang government builds this zone as a platform to attract hi-tech companies to boost the local economy to create more working opportunities and attract more talents into this local community. They want it to be charming and energetic.

These hi-tech companies which are characterized as innovation, communication and creating values set their branches here to look for more opportunities to cooperate with other companies in this zone. They also want to absorb professional people in Taicang because the government has ability and resources to cooperate with many universities to introduce out-

standing talents. Of course, employers hope their staff fit in with the company culture to be more efficient to gain greater benefits.

Because of the cooperative relationship between the Taicang government and universities most of the talents are fresh graduates who travel every day from home or rental houses to the working place. According to previous researches and interviews, most employees are young people who come from other cities or even other provinces. They are eager to start a new life in Taicang, not just a career. Although there are lots of companies in the zone and they can see many familiar faces every day, they barely talk to each other. They feel lonely after work and easy to get tired when they are working. They hope there can be a comfortable zone in their working environment for them to release pressure and communicate with others. They showed great interest if they can escape for a short voyage or role alternative during the short break of work.

However this is the current situation of the Taicang industrial zone: the construction of the whole zone is standardized. The working environment is treated as a tool not an emotional space. Functional zones like affiliated gyms are still not set up yet, there is no space for employees to relieve stress and escape for a while effectively from heavy work, not to mention make friends. It is essential for government to build its own profile and create sense of belonging for these newcomers.

## 2. Create sense of belonging for employees

### 2.2 User Requirement Analysis

The need of employees can be classified into two levels according to Maslow's hierarchical theory. A shallow level of need is characterized as their motivation to escape from their working place for a short while. This kind of need is physiological like eat and sleep. It is very common after a long-term heavy work when they get physical exhausted. They need some time or some space to relax. Besides, the contradiction between their passion for a new life style and monotony of their current situation results in their need for love and belonging. This is a higher level of need. The “tired” they mentioned to is the combination of physical and psychological. The two needs are consistent with the need of government and company essentially. What designers can do is to build the bridge between the

stakeholders to create value. If we design something which can meet the two needs, it is useful for employers and the government too.

## 2.2 Idea development

As designers, we want to create a vision of future through some smart system which can bring a defined emotion for the users. The emotion of pleasure can be created by escaping scenario to follow the users' need. Projection as a medium is a good choice to create this scenario based on current level of technology, no matter for practical use or demonstration.

Projector can create a multifunctional zone in working environment, connecting virtual and real world. However, this is not enough for higher level needs and fixed scenario means different to different users. The function of this system does not come from the images post by the projector but from the moment when users do something in this virtual environment. In other words, designers provide a platform for users to define the usability of the system.

What is the platform? How does it work? This is what we need to design. The process has to come back to the need of belonging. Belonging is a close and intimate relationship to a community. Riger, LeBailly and Gordon identified four types of community involvement of feelings [2]: feeling of bond, extent of residential roots, use of local facilities, and degree of social interaction with neighbors. In a sense, working environment is a special community which is fragmented. There need to be something to "reconstruct" it and connect the people in it to create sense of social cohesion of working together. The more people interact, the more likely they are to become close [3]. The more positive the experience and the relationships, the greater the bond is. To sum up, we need the virtual environment created by projector to connect different section of this real world working environment where employees can interact with their "neighbor". Sense of belonging can be created after some positive experiences which make them closer. However, users also have the need to escape. We hope this connection can be a boundary to make them feel safe and private. People can step out of the atmosphere anytime if they want.

How can interaction design serve for this? Different people have different emotions and as time passes

by, emotions of a person also change. How can the interactive system grow itself to intertwine with? We have to digger deeper and find answer from patina of local culture to strike the right chord.

## 2.3 Design and prototype

We want to use an indirect way of metaphor to integrate the scenario and meaning which has already accepted by users who have nurtured in Chinese culture for a long term. Such embedded scenery arouses emotion of defined scene, by implanting the meeting moment at train station into the working environment.

Why train station? It means a little different from many other countries. For example, in western countries train is one of many forms of transportation to commute to their work or for a short trip. Train station is just like a bus station. However, because of the geography and history aspects, train station relates to long farewell and reunion especially in the very moment of approaching the platform in Chinese culture (Fig 2). It has mentioned above that the young like many people in the Taicang industrial zone go far away to start their life and career in a new city, but they can hardly beat their homesickness. Although they are passionate for their new life, train station image is still the scenario they can accept. The culture is sensitive to be alone and unfixed living settlements.



Fig. 2. The moment of meeting someone on the platform means a lot to Chinese

Considering the users' motivation to go out from their office when they feel exhausted, we want to "put" them into a train which moving among colorful views created by projector (Fig 3). The train windows which are real are set in the corridors in the office building (Fig 5). The corridors are set as a railway carriage and the role

of people as employees are transitioned to passengers. Images projected are continuous visual scenery which makes user feel like in a train. The speed of users passing by is designed to trigger the interaction. We have to admit the pace of life and work is speeding up. The employees usually follow this rhythm unconsciously resulting their feeling of fatigue. We want the system to detect the speed of users passing by. If people are moving fast doing their work, the continuous scenery seen from the window is moving fast and getting blur, which is not that comfortable for people. When employees slow down or stand right in front of the window, the views will slow down to the speed in which people can enjoy the view. The installation delivers the message 'take a rest, go out for a while and relieve your tense nerve so that you can work effectively which is employer want'.



Fig. 3. People like to enjoy the view from the train window

This is the first interaction and it is certainly not enough. We just let them "go out for a while" and "escape". Where is sense of belonging? So we need the second interaction. We set up "train windows" in different floors in the office building. Different floors are like different train stations which are connected by "a moving train". So the working environment becomes a community. When there are two people standing in front of the window at a same time, they can see the "train" gradually approach the station and halt. On the platform, there is someone standing in the station waiting for her (Fig 4). When they meet each other, they communicate and interact. This kind of interaction is person to person which is flexible and emotional. The participant of an interactive public art installation is more than a passive user. Participating in creating [4] and interacting [5] with a public art installation is about transferring roles among the roles

of operator, performer, and spectator at any time. On many occasions, participants are both operating and performing, and one is also a spectator of actions of the others.

The design uses an implicit way of interaction between office workers as the relationships in the Chinese culture. The windows connect and pinch the indifference among people in the building naturally.



Fig. 4. Interaction between the employees on different floors

We made a prototype (Fig 5) of our project with some technical methods to test the usability of our idea. Due to time constraints, some functions cannot be totally achieved like speed detect. We believe these can be finished if we decide to go further when the result is ideal.



Fig. 5. Prototype

### 3. Conclusion

From the whole process of design thinking and practice, we find the form of the work of interaction design still “follows the function”, no matter the physical interface, the structure of scenery or the design of interactive behavior. The “function” of interactive design which is mentioned above cannot be judged just by the process of use. Whether the emotional needs of stakeholders can be satisfied by the interactive system is the criteria for function. The employers hope the staff of their company to be more efficient, which can be satisfied by the system even without using it. We can say it is useful for them. Designers just provide the platform for them, and the way to realize the function is designed by users. The platform is based on the research and analysis of the need. Sometimes we need to study the deep structure of local culture which nurtures the user group to make the platform unique and cannot be applied in other countries. After this process, we conclude that patina of culture is the key to determine the form and style of this interactive installation. Of course, more work needs to be done to identify more of these elements and organize them into a clear structure.

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# EVGO: A tour service system with electrical vehicle

## **Abstract**

Evgo is an actual tour service system based on connecting different scenic spots among Taihu National Tourist Resort, aiming at lightening the tourists' burden and optimizing touring experience. The system offers several services, including booking cars and touring projects online, navigation on the route, finding companions, sharing information, etc. By offering these, the information framework of the scenic spots shall be enriched by the tourists themselves, and to a large degree, it not only makes the travel more convenient, but also increasing visiting people by connecting scenic spots in series. At the same time, electric vehicle (EV) also fits the theme of travelling green.

## **Keywords**

Electric vehicle; information platform; tourist resort

## **1 Social context**

Wuxi Taihu National Tourist Resort was established in 1992 by State Council. Besides Lingshan Resort, there are Taihu Bright Pearl International Grand Hotel (in 5-star standard), Sanity Lakeside Resort (4-star), Moon Bay Resort, Taoyuan Resort, Taihu International Fishing Center, Jinghu Hotel, Yiming Resort and Lubowan Resort, etc.

However, the traffic between resorts is blocked, travelling by car is the only way, which hinders the

docking area and extension of the value chain. China also built a lot of resorts in many places, but the traffic problem between places, such as, public transportation construction lag and private cars' parking difficulties have limited the freedom of visitors, which makes a bad travelling experience. Lacking of means of transportation between scenic spots, while choosing public transportations will restrict the freedom of travel, tourists feel really inconvenient during travelling, not to mention the less information about each spot. So what if each separate scenic spot has its own vehicles, tourists can arrange their schedule all by themselves at the same time getting discount through finding companions via the platform? Moreover, tourists can synchronize their smart phones with the platform, sharing touring moments with friends at any time.

## **2 User research and concept**

After a series of researches on tourists, two important findings occurred to us. One is that long distance between scenic spots but no public transportation. The other one is according to the limited routes offered by tourist bus, freedom is badly in need. We found that a single vehicle can't meet the needs of tourists. A concept of a service system connecting scenic spots emerged. It provides EV renting and other ancillary services based on EV digital platform (Xin & Wang, 2010), mobile phone and cloud platform. It solves the problem of the traffic between different scenic spots,

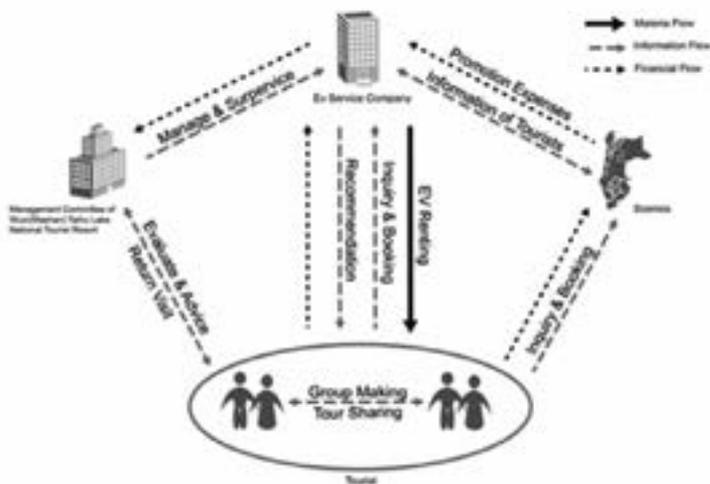


Fig.1. System map of EVGO service

aiming at bringing more freedom to tourists. Tourists can go to more scenic spots with less money. Finally the whole tour experience of tourists increases.

### 3 Solution development

**Application:** Mobile application is an important part of the service system, such as the function of payment, unlock, as well as sharing experiences will give visitors an unprecedented feeling. Before the start of the trip, visitors can scan the two-dimensional code on the vehicle to complete online reservation, payment and other projects. Then a message will be sent to tourists' phone to inform the electric key number through NGC technology unlock. The wonderful experience recorded by phone on the journey can also be synchronized to the vehicle platform to share.

**Cloud platform:** The vehicle platform as a cloud platform features to help visitors get more information about scenic spots in the form of dynamic information, offer road navigation, as well as to share experience with friends. Visitors choose their favorite photos to share, and the photos can provide references for others visitors to organize their own travel plans.

### 4 Discussion and conclusion

A single product can't meet the comprehensive requirements of users in many cases. So a systematic perspective for designers is needed. In this project, a product service system (PSS) (Manzini & Vezzoli 2003, Morelli 2003) is designed. It consists of a car renting service for the connection of scenic spots in Wuxi Taihu National Tourist Resort, an electric vehicles



Fig. 2. Scenarios of EVGO

digital platform for scenic spots recommendation, navigation, finding companions and sharing etc. A PSS as a win-win solution: winning for all the stakeholders. Value is created by taking interaction among all the stakeholders. In this project, tourists are able to visit different scenic spots freely. The resort is benefited from getting more visitors and increasing recognition. While the service provider can earn money from it. EVGO PSS opens up a new market for electric vehicles. On one hand, Electric vehicles are environmentally-friendly. On the other hand, Electric vehicles can't support long distance with one-time charge, however, it can perfectly meet the tourists' need within one scenic spot.

### 5 Acknowledgement

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# Exploring the Concept of Interactive Patina of Culture

## Abstract

Designing for different cultures is a mandatory discipline of Industrial Design in our modern, globalized world. We observe that this has a first world touch most of the time: industrialized countries designing for less developed countries, where the design is often only executed and products are manufactured. This results in a clear mismatch of artifacts and culture. In this paper, we present the results of a workshop on designing for cultures and introduce the concept of the Interactive Patina of Culture as a different take on this. This more balanced concept spans from designer and the process of designing to the resulting designs and products. The concept is backed by our field exploration during the workshop where designers of two cultures meet and jointly realize the Interactive Patina of Culture in several products.

## Introduction

The concept of Interactive Patina of Culture is a concept in the space between cultural studies, experience design and human-computer interaction. It is one way to understand recent globalization in design, namely not in terms of cross-cultural design as a one-fits-all formula, but instead as a set of different designs centered around a common rationale, but rooted in different cultural contexts. At the same time, “patina” conveys the understanding that time and use of artifacts will result in ageing, in becoming closer to the person and

cultural identity of the user, also known as “graceful ageing”, however, this cannot be limited to the designed artifacts: the process of designing and the designer are likewise to be included in this notion. That means that design practice and the designer will – over time – work in, with, and for a cultural context.

Recently we organized a student workshop around the concept of ‘Interactive Patina of Culture’. The workshop was setup in China (Suzhou area) with participants both from the Netherlands and China. Our aim was to investigate mechanisms for cooperation on the basis of equality, by means of bringing students from two cultures together. The assignment of the workshop was to design a series of interactive public installations to be located in the city of Taicang. The concept of Interactive Patina of Culture acted as a mechanism to bring qualities of the two cultures together.

In the following, we will give a short introduction on the background of this concept, how it developed and how we pursue its further development in a cross-cultural setting. Rather than bringing the concept full circle we see this paper as ‘work-in-progress’ and as an instrument to further our understanding the concept of ‘Interactive Patina of Culture’, which will be instrumental in preparing for the next workshop that will elaborate on the topic.

## The concept of 'Interactive Patina of Culture'

The concept of 'interactive patina of culture' (IPC) is a multi-layered concept, which will be explained in the following by briefly unpacking the elements that make up the concept. By doing so we move from a rather metaphorical starting point, as most would anticipate the now decontextualized word patina, towards a deeper understanding of it, beyond the literal application:

A patina is often understood as a trace of repeated use, as a slight and partial erosion of an object's surface caused by an agent gradually and over time. The stem of a hammer acquires a sheen, a polish of repeated use by a carpenter. This polish tells a story about how an object was used.

Connecting the concept of 'patina' to 'culture' changes the meaning of it. We posit that culture 'rubs off' onto the artifacts in use. That is to say the artifacts in a culture are shaped by the values of that culture; they are part of the patina of culture. This is best elucidated by an example: during the workshop in China the authors of this paper felt intrigued by a particular rolling pin in the kitchen section of a local supermarket. A few days later one of the Chinese hosts asked us which variant of rolling pin we were so interested in, and explained that different varieties of rolling pins exist that have different thicknesses and lengths and these properties are instrumental in the type of dough that is created when using them. To us this told stories about how the way that food is enjoyed has influence on how it is made. The values of a culture are expressed in the artifacts that it produces.

Connecting interactivity to the concept of 'patina of culture' extends the concept further, but not in ways that we could immediately predict, i.e. in terms of graceful ageing and degradation in interaction design [4, 5]. In contrast, this was for us the challenge for exploration. Still, we did not extend the concept towards interactivity without reason. Bringing interactivity to the concept of 'patina of culture' gave the participants of the workshop the opportunity to explore how they could express the qualities of their cultures in interactive ways. Thus it extends the concept of 'patina of culture' beyond the artifact into new territories where the dynamism of culture is opened up and explored and where cooperation is both a mechanism to come to insights and a result.

## The workshop

The workshop took place in Taicang, a city near Shanghai and had an intentionally multi-cultural character: we explored new ways to cooperate between different cultures by bringing students and staff from different universities and continents together for two weeks. Thirty-six Chinese students and nine students from the Netherlands participated and formed nine project-groups. The project-brief was the following:

*Interactive Patina of Culture: Design an interactive installation that engages the public in the act of transforming a nondescript public space into a classy dwelling. It lets the space meaningfully grow by the interactions with the public. These interactions range from the intentional to the implicit behavior. Thus the public is instrumental in growing a valuable and thus socially meaningful public image of their city.*

Below we present three case studies that were produced in the workshop:



Figure 1. Interactive Fountain

**Interactive Fountain.** There is a Chinese tale of red carps jumping over a dragon gate. In the tale, if a red carp swims hard enough against the stream, it will reach a dragon gate. If the carp tries hard enough to jump high out of water, it will jump over the gate and become a dragon. Over the years this tale have been used as a metaphor for encouraging people to study to change their own lives and for endorsing the support for one's study from the family and the society. "There is nothing more noble than studying" (Ancient Chinese saying).

The Interactive Fountain uses back projection to project animated red carps to a (real, physical) water fountain, see figure 1. The carps swim at a lower part of the fountain and they seem to be trying hard to swim to higher

positions in the fountain. One can “support” a carp by placing a hand next to it to bring it to a higher level in the fountain. This goes on until it reaches a certain height in the fountain where it then jumps over the gate.

The installation refers to the ancient tale of the carp and engages the public in bringing the carp to higher levels. It makes the audience aware of the importance of education, but also of the cyclic nature of generations following each other and supporting each other.



Figure 2. The Temple Puzzle

**Temple Puzzle.** Chinese temples are built of wood, with stone elements. Often these temples burnt down either by accident or during wars. It has always been a tradition for people to contribute to the effort of rebuilding these temples on the ruins. A ruin of an old temple is located in one of the parks of Taicang, one of the student groups took this as inspiration for their interactive installation.

The Temple Puzzle installation uses the ruin of the temple as a real-world tangible interface for children to rebuild the temple that once stood there, see figure 2. The act of jumping on the stones from the ruins of the temple will reveal the original look of a certain part of the temple that is related to the stones. The new temple is projected on a canvas that is located close to the ruin. The installation uses an existing ruin to reinterpret the tradition of communally rebuilding the fragile wooden temples of before in case they burnt. The installation was meant as a means of playfully educating children about the significance of the past. Teaching them something about their culture but also relating their environment and even their actions to their history.

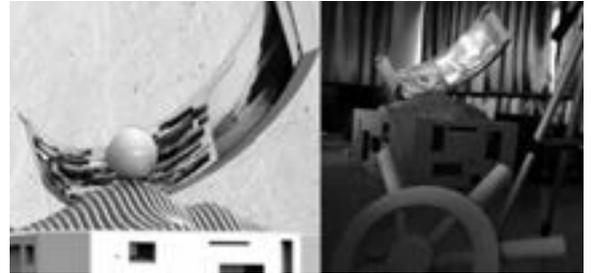


Figure 3. Moon Rising from Sea

**Moon Rising from Sea.** Taicang is a natural sea port and became the number one port of the world in the Ming dynasty, where Zheng He set off his voyages to explore the world [1]. Taicang’s cultural heritage is deeply rooted in being a seaport to the world ever since. Recently Taicang decided to exploit this past importance and fame. A building is planned that symbolizes the cultural significance of Taicang’s seaport. This building is roughly 10 by 10 meters on its base and 8 meters high and it features a large sail, and the moon rising from the waves on its roof.

The installation of Moon Rising from Sea utilizes this building to allow the public to contribute their photos from social media, for an interactive photo show projected on the sail, see figure 1. People from Taicang, who live and work overseas, will be able to send back photos and show to the people of Taicang what they are doing and seeing elsewhere in the world. Local viewers are able to browse through the photos by turning a steering wheel.

The installation enables both people who have left Taicang and people who live in Taicang to be in touch through images and allows for a connection to be crafted between people that is valuable now but also significant in light of the cultural heritage of Taicang as seaport.

In all these examples we found elements that fitted well with the concept of ‘Interactive Patina of Culture’: (1) the repeated engagement with the fountain and the cultural connotation in the first installation, (2) the cultural connotation and the relation between actions and environment in the second, and the historical reframing and the aspects of connecting people in a way that is meaningful on multiple levels for the third.

From a more critical perspective we acknowledge that none of the examples that we present in this short paper extends the concept of 'interactive patina of culture' substantially beyond simple metaphor. The case studies take an existing cultural element and make it 'interactive'. The richness that is implied in the concept of IPC in terms of historical perspectives on culture and meaning created through repeated interaction has not yet panned out. Also, the concepts are still rather generic rather than specific to the Chinese culture.

We see the value not in the results of the workshop but primarily in the process towards the results. The participants learned to value each other's perspectives and skills in the process of designing. What is more, the workshop taught us how the concept of IPC can be deepened; it set us up to create a better workshop in the fall semester.

## Conclusion

Looking back at the starting point of the workshop and the results that it yielded we feel that we can further elaborate the concept of 'Interactive Patina of Culture'. The execution of the workshop taught us very valuable lessons both on our own motives, the group process and the concept of IPC itself. In retrospect we recognize in the challenge a mechanism to cooperate between cultures. In line with Trotto we see the value of 'making' together [2], of designing together as a mechanism to generate respect and thus create a fertile ground for further cooperation. However, we also identify that we build our workshop on the implicit recognition of the unique identity of different cultures: the Chinese culture knows different artifacts and customs than the Dutch culture does. Although these differences have always been meaningful to us the present consumption, society and also design seems not to recognize these values anymore. True cultural diversity with its side-effect diversity stands in the way of efficient progression and monetization it seems. Our next step is to take the concept of IPC into the direction of culturally inspired design for diversity and we take further inspiration from the traditional artifacts that are strongly embedded in culture. Here we take cues from Sennett's concept of craftsmanship [3] and see the IPC as a value-based approach for cultural design that takes the cultural rooting of maker, the process of making and the designed artifact as the major driver of the design process. Culture is not the goal, but the starting point of design.

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