Designing for Meaningfulness in Future Smart Products

an explorative investigation of values and physical characteristics

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AN EXPLORATIVE INVESTIGATION OF VALUES AND PHYSICAL CHARACTERISTICS

BY
VANESSA JULIA CARPENTER

DISSERTATION SUBMITTED 2018

AALBORG UNIVERSITY
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AUTHOR CV

AUTHOR'S FULL CV CAN BE VIEWED AT HTTPS://WWW.LINKEDIN.COM/IN/VANESSAJCARPENTER/

Vanessa obtained a Bachelor of Science in Interactive Art and Technology at Simon Fraser University and proceeded to complete a Master's degree in Interaction Design at Malmö University in 2007. She joined the Collaborative Interactive Arts Studio, illutron in Denmark (2007), and founded her own company, GeekPhysical in 2009. In 2008, she joined Copenhagen Burlesque and took over as CEO in 2016. Vanessa became a Technology Experience Designer at IdemoLab, DELTA (now FORCE Technology) in 2012 and begin this PhD in 2016 as part of her role managing the performance contract "Design Smart Things" in IdemoLab.

The above is a concise summary of Vanessa's background, highlighting academic and relevant industry experience, however, Vanessa has a diverse background in a multitude of environments and roles including: seven years with the Vancouver Police Department as a civilian; as Marketing Director for 1010tires (CA); as Marketing and Demo Manager at TAT - The Astonishing Tribe (SE); as software interaction designer at Marstrand Innovation (DK); and at a variety of other jobs and roles, not least including roller skating waitress. It is this diversity that lends itself to her lens on creativity, art, and technology.

Vanessa is an advocate for designing for meaningfulness when developing new smart products. She speaks at industry events, hosts panels and debates about the future of technology, and acts as a chair member and jury member to a variety of startup events. She also creates participatory happenings cultivating a rich community of people who are eager to explore design, technology and art. These events include everything from participatory art events with Copenhagen Grotesque Burlesque, to the annual "Design Smart Products" industry conference and the often imitated, never duplicated Friday bar meets conference, Bits and Beers.

Throughout the period of this dissertation, Vanessa has maintained a blog, http://meaningfuldevices.com/ which she has disseminated online and via talks and interviews such as the VICE Broadly article[1] discussing meaningfulness (in Danish) Vanessa's primary role in industry is to interface with companies, helping them to explore the possibilities afforded to them by new, available technologies, while reigning in their enthusiasm to ask the important question of 'why are we making this?'. It is with this lens that Vanessa begins this dissertation.

1 *https://www.vice.com/da/article/yweekb/vi-giver-producenterne-saa-meget-magt-naar-vi-ikke-forstaar-hvordan-tingene-virker-broadly.*

ENGLISH SUMMARY

Companies developing new "smart"consumer products with embedded technology face an unprecedented availability of sensors, actuators, and inexpensive electronics with which to bring their products to life today. In this context, the rise of so many "smart products" have emerged as the norm on the market, such as a smart hair brush which informs about the health of one's hair, various smart water bottles which monitor how much water you have had to drink and when, and internet connected daily devices such as refrigerators and toothbrushes. While an increasing number of companies have begun to incorporate user centred design approaches when creating smart products and services, there is little in the way of critical reflection about what types of products are being brought to market, and why they are needed.

This dissertation aims to address this phenomenon by investigating the area of "Designing for Meaningfulness" and introducing potential parameters to help practitioners explore the concept of meaningfulness and how one might design for it. The research includes both a value based investigation of the *Mechanics of Meaningfulness* and a look at the physical characteristics of products which may enable meaningful experiences, the *Manifestations of Meaningfulness*. These point to possible parameters which designers and companies can use as starting points for ideating and evaluating their products or services in terms of designing for three scenarios:

1. People-to-people connections
2. A person to their sense-of-self
3. People-to-time

Each of these scenarios is presented as takeaways in this dissertation, utilizing annotated portfolios as a way to compare and contrast the work done and to extract the takeaways for future researchers.

This work utilizes a programmatic approach to research through design as a methodology, creating seven *engagements* which take the form of early electronic sketches. The knowledge gained from the creation and evaluation of these early sketches act as a vehicle for this research, exploring and exemplying the potential properties of designing for meaningfulness, namely the Mechanics and Manifestations of Meaningfulness.

The research which informed the creation of the Mechanics and Manifestations of Meaningfulness is split into three segments. First,, prior work is briefly examined to provide the groundwork for initial thoughts about designing for meaningfulness. Next, the seven engagements created as part of this research are presented and the qualities of meaningfulness

are exemplified through these. Finally, research collaborations are done with companies in the form of interviews, seminars and workshops, where the attitudes towards designing for meaningfulness are gathered, and the relevancy for industry practitioners is explored.

This work, while based in industry via six years of developing smart products, is significantly informed by and compared to academic research which implicitly, but not often explicitly, refers to meaningfulness as a design goal. Every aspect of this work, except the past projects, relates back to academic research and examines how other researchers have approached the topic, highlighting where gaps exist and where the opportunity for designing for meaningfulness emerges. It concludes by suggesting that Metrics of Meaningfulness can and should be created, evaluated, and standardized to offer a tool to industry and academia to utilize while ideating (if designing a new product) or evaluating an existing product.

RESUME IN DANISH

Virksomheder, der udvikler nye "smarte" forbrugerprodukter med indlejret teknologi, har nu adgang til en overflod af sensorer, aktuatorer og billig elektronik, som i dag kan bringe deres produkter til live. I denne sammenhæng er væksten i antallet af "smarte produkter" fremkommet som normen på markedet, hvor man for eksempel nu kan få alt lige fra en smart hårbørste, der oplyser om hårets sundhed, forskellige smarte vandflasker, der overvåger, hvor meget vand du drikker og hvornår, til internetforbundne husholdningsapparater så som køleskabe og tandbørster. Mens et stigende antal virksomheder er begyndt at indarbejde brugercentrerede designtilgange, når de skaber smarte produkter og tjenester, er der ikke megen kritisk refleksion over, hvilke typer af produkter, der bringes på markedet, og hvorfor disse er nødvendige.

Denne afhandling har til formål at tage fat på dette fænomen ved at undersøge området "Designing for Meaningfulness" (Design for Meningsfuldhed) og introducere mulige parametre til at hjælpe designere med at udforske meningsfuldheds-konceptet, og hvordan man kan designe i overensstemmelse med dette. Forskningen omfatter både en værdibaseret undersøgelse af

"Mechanics of Meaningfulness" (meningsfuldhedens opbygning) og et kig på de fysiske karakteristika ved produkter, der kan muliggøre meningsfulde oplevelser, dvs. "Manifestations of Meaningfulness" (hvordan meningsfuldhed bliver manifiesteret). Disse peger på mulige parametre, som designere og virksomheder kan anvende som udgangspunkt for idéskabelse og evaluering af deres produkter eller tjenester i forhold til design inden for tre scenarier:

1. Forbindelser mellem mennesker
2. En person til deres selvopfattelse
3. Mennesker-til-tid

Hvert af disse scenarier præsenteres som nøglefaktorer i denne afhandling, idet annoterede porteføljer anvendes til at sammenligne og finde forskelle mellem arbejdet i denne afhandling og udlede nøglefaktorer for fremtidige forskning.

Dette arbejde anvender en programmatisk tilgang til forskning gennem design som en metode, der skaber syv "engagementer ", som tager form i tidlige elektroniske skitser. Den viden, der er opnået ved skabelsen og evalueringen af disse tidlige skitser, fungerer som et middel for denne forskning ved at udforske og eksemplificere de mulige egenskaber ved at designe for meningsfuldhed, nemlig meningsfuldhedens betydning og manifestationer.

Den forskning, der afstedkom oprettelsen meningsfuldhedens betydning og manifestationer, er opdelt i tre dele. Første undersøges tidligere arbejde kort for at skabe grundlag for de første overvejelser om at designe for meningsfuldhed. Dernæst præsenteres de syv engagementer, der er skabt som en del af denne forskning, og meningsfuldhedens kvaliteter eksemplificeres gennem disse. Endelig gennemføres forskningssamarbejde med virksomheder i form af interviews, seminarer og workshops, hvor holdningerne til design for meningsfuldhed indsamles, og relevansen for praktikere inden for industrien undersøges.

Dette arbejde, der bygger på 6 års udvikling af smarte produkter i industrien, er i særdeleshed baseret på og sammenlignet med akademisk forskning, som implicit men ofte ikke eksplicit, henviser til meningsfuldhed som et designmål. Hvert aspekt af dette arbejde, bortset fra tidligere projekter, vedrører akademisk forskning og undersøger, hvordan andre forskere har tilgået emnet, fremhæver hvor der er huller, og hvor muligheden for at designe for meningsfuldhed opstår. Der konkluderes ved at foreslå, at "Metrics of Meaningfulness" (måleparametre for meningsfuldhed) kan og bør opbygges, evalueres og standardiseres for at give industrien og forskningen et værktøj, der kan anvendes i forbindelse med idéskabelse (hvis der designes et nyt produkt) eller evaluering af et eksisterende produkt.

ACKNOWLEDGEMENTS

I would like to begin these acknowledgements by stating what is perhaps obvious, this is far more than simply acknowledgement of everyone, it is sincere thanks, appreciation and love for the kindness, generosity and expertise which has been bestowed upon me during this PhD. This has truly been a design process with many stakeholders, reconsiderations, and many possible outcomes along the way, and I appreciate everyone who has helped me to make decisions and ultimately to learn something new about the world, about others and about myself.

Thank you to Aalborg University for your support and openness to new ideas. Thank you to my supervisor, Dan Overholt for encouraging me to do this PhD in the first place and for his support throughout this process. And a special thanks to my co-supervisor, Professor Stefania Serafin, who became a professor during the period of my PhD (Congratulations!) and was an inspiration as a woman in technology. Thank you to Amalia De Goetzen for taking the time to review this dissertation and give your constructive feedback. Thank you to Fanny Giordani who not only provided beautiful diagrams for this dissertation, but who, in making these diagrams, forced me to think in entirely new ways about how I was presenting my work and what I truly wanted to say. You have a gift, thank you for sharing it with me.

This PhD was done not as an "industrial PhD" but in industry and so I sincerely thank my workplace and work family, IdemoLab, for their patience, kindness and help throughout the years I've been trying to balance two full time jobs. Thank you to Thomas Bech Hansen for your support of me doing this PhD research in line with the Design Smart Things performance contract. Thank you to Henriette Schäfer Høyrup who has been a creative sparring partner and was the one to make it possible to transform a standard university dissertation template into my Pinterest fuelled vision. A special and heartfelt thanks to Morten Wagner, who has always checked in with me to ask how I'm doing, helping me when I needed it, and making it possible for me to take some time to spend writing and doing layout of this dissertation. Thank you.

Thank you to all the companies and the Design Smart Things advisory board and steering group who participated in this research, and contributed to workshops, seminars, interviews and studies. Your input and enthusiasm has been inspirational and I hope that you can use what I have written here in your future work.

Thank you to FORCE Technology, and the Danish Agency of Science, Technology and Innovation under the Ministry of Higher Education and Science and the Welfare Tech Innovation Network for Health and Welfare Technology for believing in the relevancy of "Designing for Meaningfulness" as an important and worthy research area to invest in, and making it financially possible to do this research.

Many people lent me their ears and advised me throughout this process. Thank you to all of you, and a special thanks to Henrik Svarrer Larsen for our walk and talks, to Mads Høbye, for always picking up the phone, and for your advice about the structure of the dissertation, to my fellow PhD students and co-authors from other universities, your camaraderie and support has meant so much. Many thanks to Tomas Sokoler and Anna Vallgårda, who took time to help me better understand the world of academia, who coached me, and gave me critical feedback about my work just when I needed it. Thank you both so much for your time. Thank you to Vasiliki Tsaknaki, for your amazing work in preciousness and sending me your dissertation so I could learn from you. Thank you to Elisa Mekler, for all our conversations about meaningfulness, many inspiring hours on Google Hangouts, and a great collaboration. Thank you to Carl Alviani for many inspiring conversations, I hope we get to write together one day soon.

Thank you to the universities I visited as part of my stay abroad for their warmth and hospitality: the UBC SPIN lab, especially Soheil and Laura, and to my old hood, Simon Fraser University and the Everyday Design Studio, especially Ron Wakkary for having a good chat about meaningfulness. Thank you also to the Sketching in Hardware group. You have been an inspiration and your input has been invaluable, especially Sophi Kravitz and Noam Zomerfeld, thank you for our talks.

I was inspired to write this PhD for a number of reasons, and when I first began, I was in the middle of a course about wearables in jewellery design where I had been invited to speak and teach by Petra Ahde-Deal. She kindly gave me a copy of her own PhD and it was through her dissertation and this course that I really came to have the first thoughts and projects about designing for meaningfulness, so thank you Petra. And furthermore, thank you to the hard working, incredible students of that jewellery design class, especially the mothers of Fibo, who became an extended family of sorts as we tried to bring Fibo into the world. A sincere, heartfelt thank you to Sandra Pétursdóttir, who sits beside me as I write this, and who has been beside me throughout this entire process, first, as a new entrepreneur, running First Bond Wearables, then as my life-saver in IdemoLab, helping to keep on top of everything when I was neck deep in my PhD, and finally, as my comrade-in-InDesign as we spent a month working side-by-side, transforming a Google

doc into this book you are holding now. Thank you for all the amazing work you did, the graphical miracles, and the many laughs along the way.
Part of this dissertation is dedicated to my past. To the projects, people, and happenings that made me who I am and shaped my 'lens' on the world. illutron has been my family, the place I explored and discovered myself as a creative, as an artist, as a hacker, as an event organizer. Thank you for including me and for the incredible projects we've done together which led me to think about the Mechanics and Manifestations of Meaningfulness. GeekPhysical was my first foray into having my own business in Denmark and was where I learned so much about creating interactive technology. And Copenhagen Grotesque Burlesque has been where I have been able to express my creativity and cultivate a community of participants, experimenting with my ideas before I move them into industry. Thank you to these families for their patience every time I said "I can't, I'm too busy".

A special thank you to the many inspirational female power houses who have been sparring partners along the way: Shannon, Becky, Nina, Majken, Tina, Nynne, Maria, Mona, Magda, Lisbeth, Amanda, Irina, Felicia, Malene, Mirjam, Sisse, Maja, Susanne, and so many more. If I've forgotten you here, know you are in my heart.

And on a personal note:

Thank you to my parents for always asking how it was going even though they were literally a world away in Canada. Thank you for always supporting whatever crazy idea I had, and inspiring me to be an artist, a speaker, a leader, and for encouraging me to rest when I needed it. Tak Lene og Bjarne for jeres tålmodighed med mig og jeres hjælp med haven og huset mens jeg havde for travlt for at gøre det selv. I er så søde.

Dzl, my husband, my partner in GeekPhysical, and co-creator of events and electronic sketches, co-author of papers, and debate opponent, has discussed every aspect of this dissertation with me. You have been my sparring partner, discussing everything from philosophy to which hardware components to use, to how we can make the world a better place. You are always there for me, cooking me breakfast while I'm on my laptop, as we half discuss a theory chapter on meaningfulness and half discuss the tasks that are needed to be done to complete one of the engagements in this dissertation, and then helping me to build them. Thank you for your precious time, your creative energy, your hard work, and your love and thoughtfulness.

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1

INTRODUCTION

1. INTRODUCTION

DESIGNING FOR MEANINGFULNESS

An overview of the contents of this dissertation will be described in Chapter 3. Before that, I present a vignette, a glimpse into a product I've been helping to develope to demonstrate what I mean by 'designing for meaningfulness'. Following this is Chapter 2: the methodology used throughout this research period as it contains much of the terminology I will use throughout the dissertation. In Chapter 3, I explain where this research has been situated, namely, in industry where I have worked for IdemoLab, FORCE Technology for the past six years, and continued to work there throughout the entire period of this research. My PhD is part of a 3 year project I am managing called "Design Smart Things" which is funded by the Danish Agency for Institutions and Educational Grants, a part of the Ministry of Higher Education and Science. In Chapter 3, I introduce a preliminary overview of how I frame meaningfulness as a concept, including the terminology used throughout this dissertation. I then present my research questions, a summary of the contributions of this work and an overview of the PhD structure.

To set the tone for what I mean by meaningfulness, a vignette of one of the projects in this PhD is presented here. With tremendous thanks to Sandra Pétursdóttir, the founder and mother of Fibo and First Bond Wearables.

1.1 Vignette:

> *A woman, quite pregnant in her third trimester, can feel the kicks, pushes, hiccups and movements of her baby. She is sometimes delighted, sometimes frustrated, and sometimes exhausted by this. She wants to share the experience with her partner but it's hard to describe other than "the baby is moving!". She waits for her partner to come home from work, and after dinner, sitting on the couch, the baby begins to kick. She invites her partner to place their hand on her belly and by the time they reach the couch and place their hand there, the baby is resting and has stopped kicking.*

Fibo, by First Bond Wearables, is designed to help the partner be involved in the pregnancy. The creators of Fibo heard this exact story from many couples. Partners were frustrated they couldn't be more involved in the pregnancy and were often first having an 'ah-ha' moment when they heard the sonogram of the baby's heart rate or felt a kick, or, held the baby in their arms for the first time. Fibo is a wearable for partners of pregnant women, which allows them to tangibly feel the movements of the baby on their inner wrist. Fibo was originally designed as four beads of different shapes which would rotate so the partner could feel kicks, pushes and hiccups as they happened. With Fibo, the scenario becomes:

> *A woman, quite pregnant in her third trimester, can feel the kicks, pushes, hiccups and movements of her baby. … She wakes up and puts the baby monitoring patch on her belly. Her partner awakens and puts on Fibo, a wrist-worn wearable allowing them to feel the movements of the baby. They begin their day and her partner goes to work. Throughout the day, they can feel small and big kicks, hiccups and pushes as they baby is active throughout the day. When they arrive home later that night, they rush in to speak to the mother, stating, "wow, what did you eat for lunch? The baby had the hiccups for half an hour, that must have been rough on you!"*

Through using Fibo, the partner becomes connected, tangibly, viscerally, to the baby. They begin to connect at an earlier stage, to identify as a parent, to learn how the effects of the adult affect the baby. They connect more deeply with their partner as they realize just how often the baby is moving and how intensely. The partner grows closer to the baby and the mother and also develops their own personal identity as a parent. This is an example of *designing for meaningfulness.*

2

METHODOLOGY

2. METHODOLOGICAL APPROACH

A PROGRAMMATIC APPROACH TO RESEARCH THROUGH DESIGN

This PhD has utilized a programmatic approach to research through design (Redström, 2017), wherein the fundamental quality is a non-linear exploration of a design space which unearths aspects of the programme as it unfolds. Below I present a brief overview of research through design as a method in the context of interaction design.

In this dissertation, I follow the definition of interaction design as recently described by Löwgren, Larsen and Hobye (2013) who present five aspects of interaction design: (1) artefacts acting as catalysts for transformation, which are (2) curious in nature and therefore explore possible futures, thus (3) framing design situations and proposals which are represented and explored via tangible sketching, enabling thinking through making (4) and consider a range of qualities (5) including instrumental, technical, aesthetic and ethical.

Within interaction design exists the method of Research through Design (RtD) which was coined in 1993 by Frayling and debated since then ((Zimmerman, Forlizzi and Evenson, 2007), (Bowers, 2012), (Zimmerman, Stolterman, and Forlizzi, 2010), (Blythe, 2014), (Hobye and Löwgren, 2011), (Bardzell, Bardzell, and Hansen, 2015)). Gaver investigates this debate, and describes RtD as "Design, and research through design, is generative. Rather than making statements about what is, design is concerned with creating what might be(…)" (Gaver, 2012). This exploration of what might be and a focus on the future (Zimmerman, Stolterman, Forlizzi, 2010) is the foundation of research through design, upon which many other ways of researching are placed. (This is explored extensively in Zimmerman, Stolterman and Forlizzi's 2010 and Bang & Eriksen, 2014). Gaver describes that there exists a general consensus on what RtD is, relating to Löwgren, Larsen and Hobye's (2013) five points above: it is user centred, "exploring a wide space of potential designs, whether through sketching, scenarios, narratives or design proposals" and the "practice of making is a route to discovery". (Gaver, 2012). Zimmerman (2007) describes research through design as a method to find the 'right thing' wherein design artefacts which go through a process of "ideating, iterating, and critiquing potential solutions" act as exemplars which reframe the problem.

Adding to, or intertwined with this, is constructive design research (Koskinen et al.. 2011) wherein the artefact which Koskinen et al.. explain can include "product, system, space, or media" and "becomes the key means in constructing knowledge" (Koskinen et al.. 2011). For Koskinen et al., the role of a constructive design researcher is to "imagine new realities and build them to see whether they work. The main criterion for successful work is whether it is imaginative in design terms. Theirs is a science of the imaginary" (Koskinen et al. 2011). The future as explored by RtD is also referred to as "research through design fiction" by Blythe (2014) who highlights the role of fictional narratives as a method for exploring the potential futures of the prototypes explored in a research through design process.

From this stance of generative artefacts comes the programme. Utilizing a programmatic approach to research through design is a way to explore a design space and create a framing of that space (Löwgren, Larsen and Hobye , 2013). Bang and Eriksen (2014) agree that the programme is a frame, and focus more on the experiments as being framed (rather than, or in addition to, the design space), which allows for "surprises and new insights arising from the experiments" which in turn, causes the programme to drift (Koskinen and Krogh (n.d.)) and be re-framed which fits with Koskinen et al.'s description of the constructive research programme, as imagining new realities. In another work, Koskinen, Binder and Redström explain that progress in research occurs when design experiments add new knowledge to, or corrects a programme (2011). The notion of the program (or programme) is explored extensively by Redström in his recent work (2017) wherein he describes the role of the research programme as being "oriented more toward problem finding than problem solution", as "critical and projective" and as a focus on the "development of the questions asked and the hypothesis posed" instead of on the advancement of prototypes. In exploring the concept of the programme, Redström further specifies that the programme is "characterized by both intent and unfolding", "depends on a certain worldview" and "is not indefinitely continuous but must come to an end when its worldview is fundamentally questioned". These aspects will be elaborated on in relation to Figure 1.

Within the programme exists design experiments, the generative artefacts mentioned previously. Koskinen, Binder and Redström (2011) introduce the concept of a gallery (as opposed to a field or a lab) wherein the gallery displays work which might be conceptual, and "This format implies that the design experiment, be it a model, a prototype, or a performance, is the final presentation of the work and its process". This can be seen as a kind of design experiment, an artefact which is in a process of research through design, generating knowledge to drift a programme in a yet unknown direction.

This explorative, future facing programme is holistic and flexible

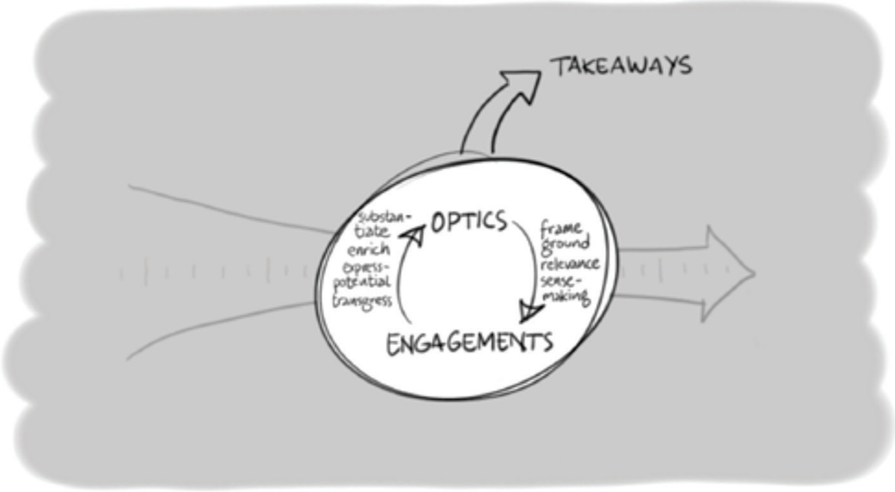


Figure 1: Löwgren, Larsen and Hobye's (2013) diagram of a programmatic approach to research through design.

(Löwgren, Larsen and Hobye , 2013) allowing for a degree of movement, both within the design experiments and of the overall programme itself. In Figure 1 a diagram is presented by Löwgren, Larsen and Hobye (2013) and includes takeaways, optics and engagements. Following, I explain this diagram as explained by Löwgren, Larsen and Hobye (2013). The arrow through the centre indicates the nature of the drifting of the programme.

Optics

The optics refers to the way of seeing or thinking that exists as part of the programme. This can be seen as the worldview as described by Redström (2017).

Engagements

The engagements are the design experiments, generative artefacts, and as Löwgren, Larsen and Hobye explain, "referring to all manners of design interventions and constructive actions" (2013). I am particularly interested in the term 'engagements' and how it refers to engaging with said design experiments and artifacts. This engagement '*with*' is vital to my research, as it allows for exploration of both the values and the physical characteristics of meaningfulness.

Takeaways

The programme leads to takeaways, or lessons learned, qualities found, which are not the programme itself, but rather qualities which are extracted from the programme.

Designing for meaningfulness as a programme

This collection of engagements, design experiments, encounters, conversations, interviews, and desktop research arose from my past work (my worldview) of developing everything from artistic interactive installations to consumer products, and forming a question about what a smart product designed to enable a meaningful experience might look act, and be like. The aim of my research was therefore to explore this design space, to discover what I may about the physical characteristics of these objects and about what meaningfulness as an abstract term might come to mean in terms of interaction design. It has been a process of exploration and discovery, generating insights, and communicating these to the research community to see which might be relevant within interaction design.

Within this dissertation, the engagements are case studies - design artefacts developed as exploratory vehicles to discover and map a design space. The optics are programmatic research through design, and a stance on designing for meaningfulness is developed as per other 'designing for-' paradigms, such as: designing for happiness (Hassenzahl et al., 2013), designing for authenticity (Su and Stolterman, 2016), or designing for homo explorens (Hobye, 2015). The three primary takeaways are outlined in the chapter entitled "takeaways". Figure 2 is a diagram of this programme. These diagrams have been developed in collaboration with Fanny Giordano, PhD Student in Service Design, Department of Architecture, Design & Media Technology, Aalborg University.

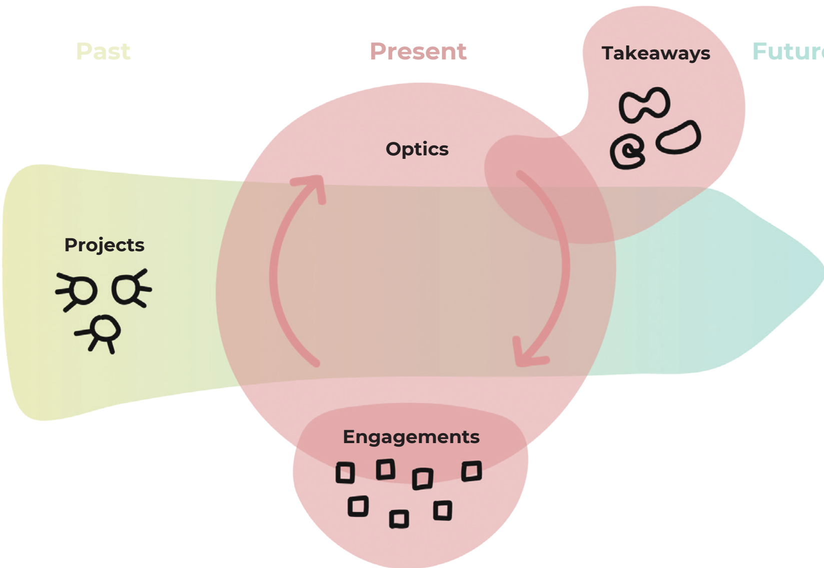


Figure 2: Adapted from Löwgren, Larsen and Hobye's (2013) diagram, this incorporates my past projects from three domains, the seven engagements created as part of this dissertation and the three takeaways emerging from this work. Diagram by Fanny Giordano.

3

DISSERTATION

3. INTRODUCTION

THE DISSERTATION

Introducing FORCE Technology and IdemoLab

This PhD is part of a three year Performance Contract with the Ministry of Research and Innovation in Denmark: "Design Smart Products" led by myself - Vanessa Julia Carpenter at IdemoLab, FORCE Technology (Previously: DELTA (Danish Electronics Lights and Acoustics)). This contract explores how we as Interaction Designers, User Experience Designers, Engineers, and other stakeholders involved in a process, create "Smart Products". Smart Products, as a term, refers to new (or upgraded) devices which utilize sensors, actuators and microcontrollers to create useful interactivity and services for the users. The primary focus of this dissertation is in enabling meaningful interactions via thoughtfully designed smart products. This project has also been supported by Welfare Technology, Denmark, and has been part of their network about innovation, health and welfare technologies.

Smart products - a framing

The below is provided as context for the starting point of this dissertation. While firmly rooted in the design of smart products, a programmatic research through design approach was adopted, and the emerging qualities from this process are the contribution of this dissertation. When I refer to smart products, I refer to consumer facing devices with embedded technology. What follows is the positioning of the abovementioned Design Smart Products performance contract in relation to the PhD as originally written for the proposal of this dissertation (references within this excerpt have been included in this dissertation for convenience of reading and referral):

> Within the field of smart product development, there is much hype around the creation of internet enabled devices (Bughin, Chui, and Manyika, 2015); companies are eager to implement "smart devices" and there is an increasing need to understand that "it won't be enough to focus on the product features customers will pay the most for" (Bughin, Chui, and Manyika, 2015) but rather the why of creating these devices is important to incorporate. This is especially the case with an IoT (Internet of Things) device, with the release of articles such as McKinsey's "By 2025, Internet of things applications could have $11 trillion impact" (Manyika and Chui 2015). Companies in Denmark use GTS institutes (Approved Technology Companies / Godkendte Teknologiske Serviceinstitutter such as DELTA for help with creating these new devices. In recent years, there has been a

significant increase in the number of off-the-shelf technologies available for prototype building; namely new sensors, actuators, and open source platforms on which to build these new products and interactions (Kasperkevic, 2013). This increase in readily available technologies, combined with the popularity of the IoT as a new market, creates a demand for new smart products and for researchers to contribute to this development in terms of considering the implication of many new smart products in our lives and how we should design for this.

3.1 A brief Introduction to a Lens of Meaningfulness in Tangible Computing

Within this dissertation, I maintain a framing of meaningfulness, as the term meaningful is problematic, at best. The term meaningful alone is difficult to define, as I delve into in Chapter 10: Discussion, and further, what is meaningful to one person is not necessarily meaningful to another.

As this dissertation progresses, the meaning of meaningfulness becomes clearer, and Chapter 8: Findings aims to answer this.

On a top level framing of this dissertation, my framing of meaningfulness concerns **people-to-people connection, a person-to-their sense of self and a person to a sense-of-time**. (Carpenter and Overholt, 2018). (Figure 3).

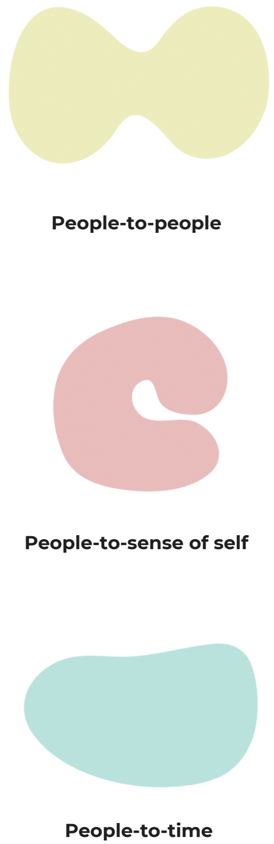


Figure 3: My framing of meaningfulness, focusing on the links between people, between a person to their sense of self and between a person to a sense of time. Diagram by Fanny Giordano.

These are the three takeaways presented at the end of this dissertation and throughout, a focus on the critical thinking resulting from these connections is explored in regards to designing for meaningfulness.

These three aspects can be combined in a multitude of ways. There can be people-to-people connection which causes a person to look into their relationships, there can be a person's sense of self reflection and growth which causes them to look to who they have been and who they want to be. There can be people-to-people connection which asks people who they want to become together. All of this involves critical thinking, reflecting and acting on some level. Throughout this dissertation, I will present representations of these icons as they relate to a particular project or engagement (Figure 4).

Many researchers have approached similar topics, these are outlined in the *Theoretical Drifting* section of Chatper 5. A few have begun to discuss meaningfulness in technology such as Ghellal (2017), Hassendahl (2013), Mekler and Hornbæk (2018) and others. Meaning-making is also discussed extensively in HCI (Human-Computer Interaction), however due to the terminology issue, meaning-making can range from making sense of something to gaining meaning from an experience, the latter of which I focus on in this dissertation. I present meaning-making in Chapter 5 and refer to it again in Chapter 10:

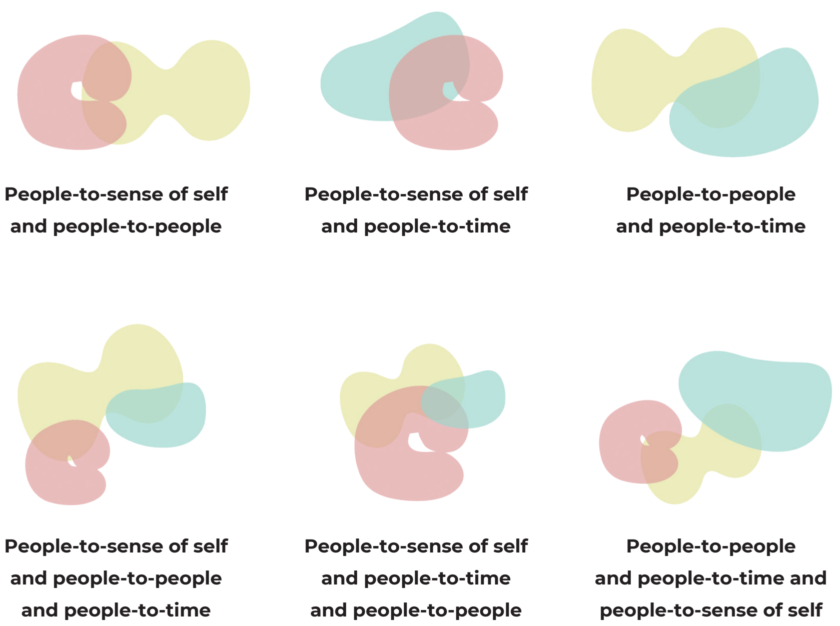


Figure 4: These links can be combined in a variety of ways. Some engagements might have one or two or all three elements. In the combinations of three, one element might be more significant than the others. Diagram by Fanny Giordano

Discussion as a way to map where meaningfulness exists in academia. I am particularly interested in meaningfulness as it relates to smart products. Therefore I look to the history of physical computing (O'Sullivan and Igoe, 2004) and tangible computing (Dourish, 2004) as a starting point. I am concerned with the consumer facing smart products which are being brought into the world and how these impact designers and end users in terms of their personal values, reflecting (critically thinking), and *acting* on their sense of fulfilment in life as it relates to the three aspects (Figure 3).

I see smart products as catalysts, propelling people to think, act, and contribute to meaningfulness in their own lives which I elaborate on in Chapter 10: Discussion.

I look to research which asks how we might, for example, *design for authenticity* which Su and Stolterman (2016) explain might "allow us to understand the ways in which we try our best to live fulfilling and worthwhile lives with technology." Or how we might *design for happiness*, which Hassenzahl et al. (2013) describe as "designing intangible experiences fueled by need fulfillment". Or how, as Light, Powell, and Shklovski (2018) explain, we can "save humanity" by reflecting on "fundamentals of existence" as "going towards the future with grace and bravery is simply better than travelling with fear, small-mindedness and hate. It makes for a better- fulfilled life". These aspects of life fulfillment tie in strongly to eudaimonic design for life purpose and fulfillment (Mekler and Hornbæk, 2018). While these areas (and many more, described later) do explore aspects of this framing of people-to-people connection or people-to-self connection and critical thinking, none explicitly refer to meaningfulness, as more than a passing term, such as a 'meaningful experience' or a 'meaningful outcome'.

It is here that I point to a gap in knowledge, where a new perspective on existing research emerges: grouping the various research areas which all seemingly point to meaningfulness but do not explicitly name it. From this perspective, I present my engagements: early sketches which act as vehicles of research to explore and generate intermediate level knowledge (Löwgren, 2013) which informs my proposal of the Mechanics of Meaningfulness: aspects of meaningfulness which I encounter throughout my work, and the Manifestations of Meaningfulness (the physical characteristics) of smart products which may enable meaningful experiences.

I contribute with an initial mapping of meaningfulness as a term within HCI, a proposal of value based aspects and physical characteristics which contribute to the form of the smart product being developed. Further, I point to a future research agenda to propel this area of research further; both in academia and in industry.

3.2 Research Questions

The purpose of this PhD has been to study which characteristics of smart products might enable aspects of meaningfulness to emerge as a result of engagement with the products. This has been done through a primarily practice based approach, using a programmatic research through design method (Redström, 2017) wherein a series of early sketches has been developed to explore potential value based and physical based characteristics and which engages companies in discourse about what it is to design for meaningfulness. From this stance, my research questions are:

1. How might we conceptualize designing for meaningfulness within interaction design to benefit industry who are developing consumer facing smart products?

2. What might be the Manifestations of Meaningfulness of a smart product which acts a catalyst for personal meaningfulness?

The first question is answered by the results of the second question in that to understand what might be meant by designing for meaningfulness, I utilized a programmatic approach to research through design and a series of early, tangible sketches (Buxton, 2010) which were designed, built and evaluated in terms of the Mechanics (value-based) aspects of meaningfulness, and the Manifestations (physical characteristics) of meaningfulness. These are explained and explored in Chapter 6: Engagements. These opened up for an exploration of the design space of meaningfulness in interaction design.

3.3 Terminology and Language used throughout this Dissertation

Chapter numbers

I will refer to chapter numbers to direct the reader where to seek upcoming or previous information about the topic in question. These will appear in parenthesis such as (2.4).

I, we, user, person

During the period of this PhD, I have worked in many different collaborations. ***I*** refers to myself, as I have been writing this dissertation and I present my own reflections and conclusions here as an individual.

We refers to a particular project team. This might be IdemoLab, the industry group I work in as my daily work. It might be a project group, such as the group who developed Fibo, the pregnancy wearable. I aim to be as specific as possible when crediting people for their contribution and who is defined in a particular use of 'we'. On the note of credits, photos are credited with the photographer. If there is no credit provided, it is because I have been the photographer for that photo.

I prefer the term 'people' to 'user' and try to use this as often as possible however there are times when 'user' simply makes more sense for that sentence so I then use 'user'. Finally I use the term 'participant' in preference over 'people' or 'user' as my aim in designing and deploying engagements has been to engage people as participants, actively contributing to knowledge contribution.

Smart product
As earlier defined, a smart product in this dissertation refers to a consumer facing product which utilizes embedded technology. An example of this might be a smart water bottle with an embedded sensor to detect how much water is in the bottle and then providing a notification via app when it is time to consume more water.

Gadget
Occasionally I use the term gadget. I use this colloquially as I've encountered it in industry, as a reference to smart products designed for fun, novelty or convenience but without much further thoughtfulness in design, or intention to last longer than it is interesting. A typical example is a product which has since gone out of business, the Kuvée wine bottle (Kastrenakes, 2018), essentially a screen on a wine bottle which offers information about wine in the bottle.

Industry
By industry, I refer to the companies, organizations, practices and happenings such as knowledge sharing events which are non-academic in nature. This is where I am situated, in a company with customers who develop smart products for companies aiming to bring new smart products to market.

Language
Throughout this dissertation, I aim to avoid complicating the language with unnecessary use of words which can be said in a more straightforward manner. I hope that this dissertation may be read by researchers of any level, who may not have English as a first language as I myself live in a country where English is the second language. I hope it can be read and used by industry, who might not be used to academic formalities of language - not that they couldn't understand it, they certainly could, instead my aim is to avoid complicating the terminology when the same thing can be said more simply. Similarly, I steer away from innovation words such as "disruption" (in the industry sense of the word) as I believe these are not well defined enough to describe things in a straightforward manner. (I discuss this further in Chapter 10: Discussion). The exact challenge I've faced with a PhD about "meaningfulness" is in the understanding of the term; and I don't dare complicate that further with either academic or industry terminology when it can be said in a clearer manner to (hopefully) the same effect.

My goal is to enable more people to benefit from this research. In conducting this PhD, it has taken me considerable time and effort to be able to read some extremely useful and world-benefiting academic papers. In industry, I haven't the time nor the motivation to search academic databases to find articles which might be relevant, and just as likely might not be relevant to my work or which I understand immediately given the terminology used in any particular paper. Therefore it is my hope that in presenting this dissertation in a straightforward manner, anyone can benefit from the research I have conducted.

3.4 PhD Structure

The structure of this PhD is presented through engagements with the sketches, the case studies conducted during this research - henceforth referred to as the ***engagements***.

As the nature of each of the engagements covered different topics, ranging from jewellery devices to breathing awareness to traditional craft and music creation, papers with related works in these specific topics were written for each. The literature review covered in this PhD focuses primarily on meaningfulness in interaction design, and how a research through design approach leads to intermediate level knowledge which informs an annotated portfolio for each aspect of designing for meaningfulness. Thus the structure of the PhD is represented in Figure 5.

Background: Chapters 4 & 5

The method has been introduced: a programmatic approach to research through design. This is an iterative, exploratory method, gaining insights along the way with no end goal, instead the goal is to explore. From this stance, a prelude is presented of my own background (Chapter 4) followed by Chapter 5: where I introduce a genealogy as a brief overview of projects which informed the lens through which this PhD is constructed. We then move to theory, looking to topics within interaction design which have a two sided approach: Tangible interaction with physical computing, and a structure of "designing for x…" in interaction design where 'x' represents a particular topic.

Engagements: Chapter 6

Each engagement will be presented as a stand-alone case in this chapter. Seven cases in total will be presented representing the artefacts created during this PhD. Each engagement presents a use case scenario, the collaborators on the project, the concept, the hardware, the intended experience, the actual experience, and the emergent qualities of the interaction. Each of the engagements is presented as a sketch, brought into context, explored, a hypothesis expanded upon, and qualities derived from this exploration. Here, I turn to Klemmer, Hartmann and Takayama (amongst many others) who highlight the benefit of this approach:

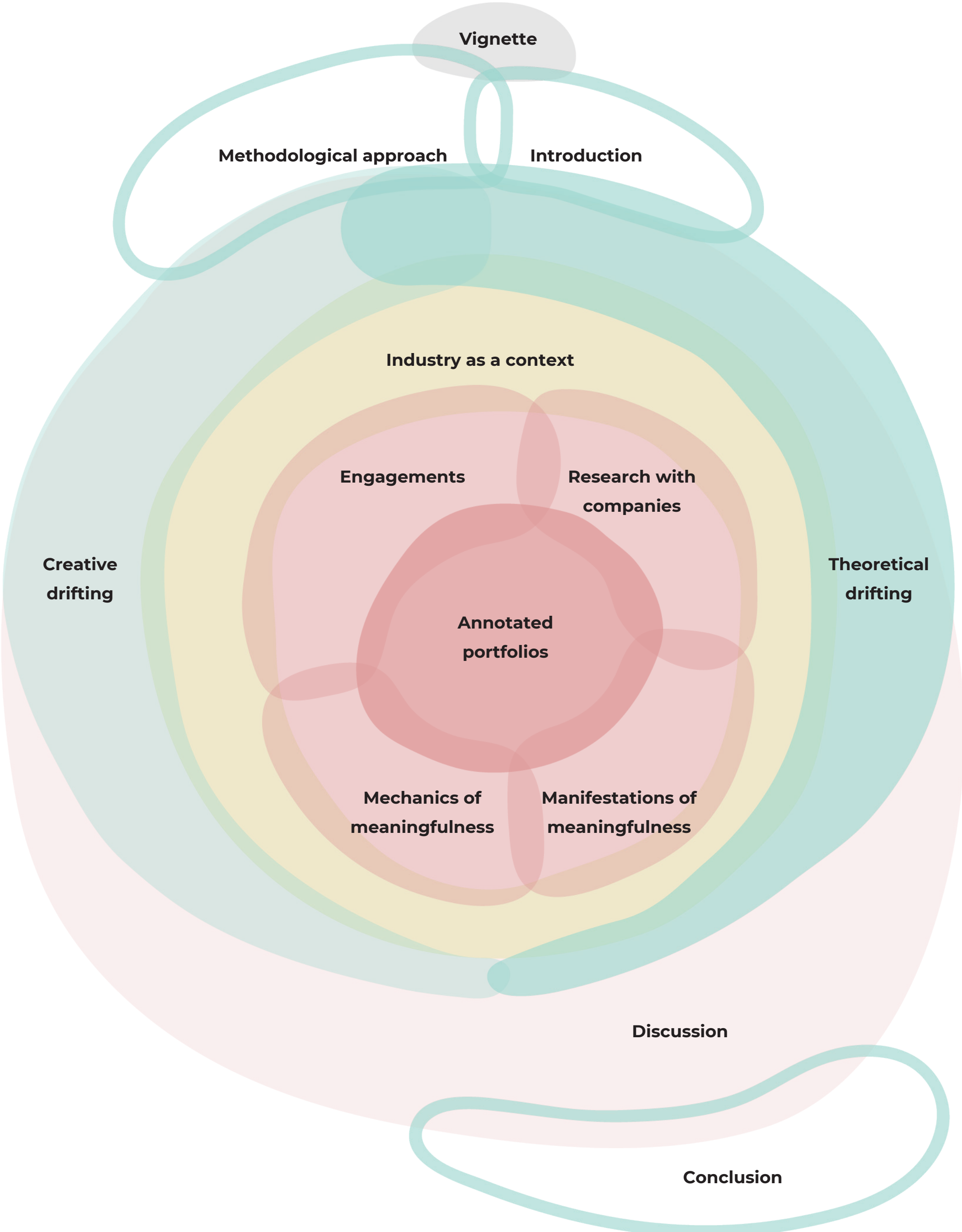


Figure 5: An overview of the dissertation with elements converging in the centre and emerging in the discussion and conclusion. Diagram by Fanny Giordano.

“The epistemic production of concrete prototypes provides the crucial element of surprise, unexpected realizations that the designer could not have arrived at without producing a concrete manifestation of her ideas.”

(Klemmer, Hartmann, Takayama, 2006)

While each engagement on its own is physically no more than an early prototype, the overall concept, reactions, discourse, understanding of interaction and potential for meaningfulness form the result.

Research conducted with companies: Chapter 7

As part of the research conducted during this PhD, I worked extensively with companies to explore their reactions to, and understandings of designing for meaningfulness. In this chapter, I present insights from industry arising from interviews, seminars and workshops. This informs my work in terms of establishing relevance for industry and confirming the interest in and importance of the Mechanics of Meaningfulness and the Manifestations of Meaningfulness, as presented in Figures 6a and 6b.

Research Question Findings: Chapter 8

In this chapter, I introduce the Mechanics of Meaningfulness, aspects which emerged as potential value-based qualities of meaningfulness. I also present the Manifestations of Meaningfulness which are the *physical characteristics* which might enable meaningful experiences, namely:

1. Non-Screen
2. Tangible
3. Craft based
4. Everyday Objects

Before moving into the dissertation content, Figures 6a and 6b present a brief overview of each of the Mechanics of Meaningfulness and Manifestations of Meaningfulness that will be then fully explained in Chapter 8: Findings.

Takeaways: Chapter 9

The three takeaways are qualities of designing for meaningfulness which are explored via annotated portfolios, one for each takeaway. Here, a mixture of the engagements and other researcher’s projects form a landscape from which we derive the three takeaways. These three links are:

1. Enabling people-to-people links to foster, maintain, or strengthen a human connections
2. Enabling people-to-sense of self links to tell or enable

Mechanics of Meaningfulness

Personal development:
Identity, purpose, who am I, who have I been, who will I be in the future?

Moments of significance:
Discovery, transformation, the ah-ha moment, leading to identity change.

Value over function:
The result of using a device, as it adds value to your life.

Meaning in everyday life:
Meaningfulness is different to every person in every situation.

Critical thinking:
Asking the hard questions, analyzing and reflecting, leading to growth.

Offline artefacts:
Non-connected is the new connected, a possible future Mechanic of Meaningfulness.

Figure 6a: These icons represent the Mechanics of Meaningfulness and will be used throughout this dissertation to represent each of the value-based mechanics. Diagrams by Fanny Giordano.

Manifestations of Meaningfulness

Non screen

Tangible

Craft

Everyday

Figure 6b: These icons represent the Mechanics of Meaningfulness and will be used throughout this dissertation to represent each of the value-based mechanics. Diagrams by Fanny Giordano.

stories and thus, help to build identity
3. Enabling people-to-time links to allow for reflection and the making of meaning.

Diagrams

Throughout Chapter 6: Engagements I will use the diagrams and symbols in Figures 3, 6a and 6b in combination to demonstrate how the qualities are present in each engagement. (Figure 7).

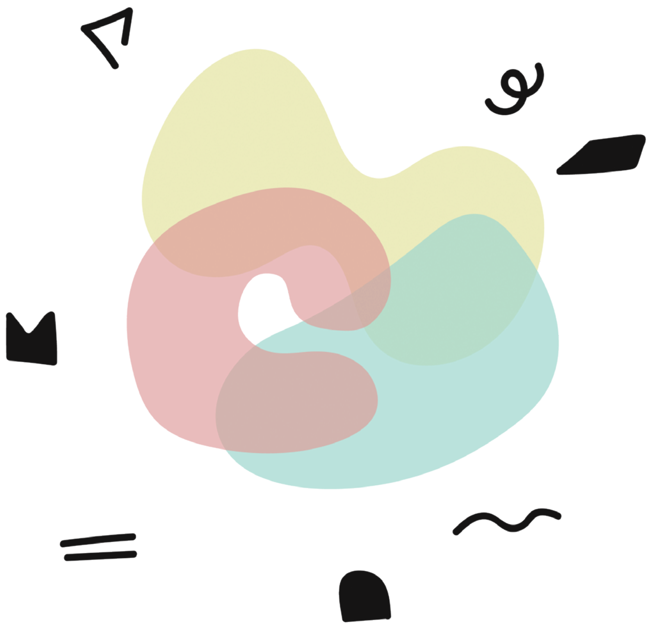


Figure 7: This is an example of a diagram showing that all three take-aways are present, people-to-people, people-to-sense of self and people-to-time, as well as the Mechanics 'critical thinking', 'personal development', 'value over function', and 'meaning in the everyday', and the Manifestations of Meaningfulness, 'non-screen', 'everyday' and 'craft'. These type of combination diagrams will be used throughout this dissertation to represent which projects contain which aspects. Diagrams by Fanny Giordano.

3.5 Summary of Main Contributions

I present two main contributions of my research. The first is the Mechanics of Meaningfulness, which can be seen as a culmination of the values of meaningfulness which stand alongside the various related works. The second is a description and analysis of the Manifestations of Meaningfulness of the engagements which lend themselves towards designing for meaningfulness. For each of my research questions below, I elaborate on the main contributions.

HOW MIGHT WE CONCEPTUALIZE DESIGNING FOR MEANINGFULNESS WITHIN INTERACTION DESIGN TO BENEFIT INDUSTRY WHO ARE DEVELOPING CONSUMER FACING SMART PRODUCTS?

The first contribution is the Mechanics of Meaningfulness, which consists of five values, namely: Personal Development, Moments of Significance, Value Over Function, Meaning in Everyday Life and Critical Reflection. These five values are derived from both the engagements with the engagements as well as interviews and feedback from companies throughout the process, and from the theory, where similar work is mapped and gaps in knowledge are identified. The knowledge put forth here can be seen as intermediate level knowledge (Löwgren, 2013), whereby the engagements and the input from companies resulted in insights which led to the development of the Mechanics of Meaningfulness.

WHAT MIGHT BE THE MANIFESTATIONS OF MEANINGFULNESS OF A SMART PRODUCT WHICH ACTS A CATALYST FOR PERSONAL MEANINGFULNESS?

The second contribution is a collection of four primary Manifestations of Meaningfulness or physical attributes which can be considered when designing a new smart product. Since this work originates from working with companies developing physical smart products, and focuses on tangible interaction, the Manifestations of Meaningfulness come sharply into focus. Here we present four qualities: non-screen, tangible, everyday and craft. Each of these is explored in detail in both Chapter 6: Engagements and though the three takeaways in Chapter 9. These aspects of physical computing, craft, interactive materials, and everyday objects are the pillars upon which this research is built. Concrete examples of how each is used are provided, and I look to related works to demonstrate how other researchers have also used these aspects. The papers included in this dissertation exemplify in detail aspects of each quality.

3.6 Publications

3.6.1 Current - Published

Carpenter, Vanessa and Dan Overholt. (2018) “Designing for interpersonal connections in future technologies: An annotated portfolio of jewellery devices”. Proceedings of the 2018 NordDesign conference, Design Society. https://www.designsociety.org/publication/40883/

Carpenter, Vanessa, Homewood, Sarah, Overgaard, Majken, and Wuschitz, Stefanie. (2018) “From Sex Toys to Pleasure Objects”. Proceedings of the 2018 British Computer Society Conference: Politics of the Machine. BCS, 2018. https://ewic.bcs.org/content/ConWebDoc/60308

Carpenter, Vanessa Julia, and Dan Overholt. (2018) "Designing For Meaningfulness: A Case Study Of A Pregnancy Wearable For Men." Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems. ACM, 2017. https://doi.org/10.1145/3064857.3079126

Carpenter, Vanessa Julia, Møbius, Nikolaj “Dzl”, Willis, Amanda, Overholt, Dan. (2018) Electronic Kintsugi: An investigation of everyday crafted objects in tangible interaction design. Proceedings of the 2018 IEEE Future Technologies Conference. Springer, 2018. https://link.springer.com/chapter/10.1007/978-3-030-02686-8_9

Carpenter, V. J., Kampmann, B., Stella, A., Maunsbach, M., Minovski, M., Ville-France, N., & Overholt, D. (2018, September). MusicFabrik: a playable, portable speaker. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (pp. 701-705). ACM. https://doi.org/10.1145/3240167.3240242

Møller, N., Overholt, D., Carpenter, V., Stella, A., Kampmann, B., Minovski, M. and Maunsbach, M. (2018). SketchyTuna: Exploring A Design For Screenless Creativity. Zenodo. http://doi.org/10.5281/zenodo.1422633. SketchyTuna: Exploring A Design For Screenless Creativity. Zenodo. http://doi.org/10.5281/zenodo.1422633

Poster: Carpenter, Vanessa and Overholt, Dan. “Provoking breath: an exploration of how to remind people to breathe”. Persuasive Technology: Development and implementation of personalized technologies to change attitudes and behaviours. 12th International Conference, PERSUASIVE 2017, Amsterdam, The Netherlands, April 4-6, 2017 Adjunct Proceedings. 2017. (pp. 22-23). http://persuasivetechnology.eu/wp-content/uploads/Adjunct-proceedings-2nd-ed.pdf

3.6.2 Accepted - Awaiting publication

Carpenter, V. and Mekler, E. Towards Metrics of Meaningfulness for Tech Practitioners. Accepted to CHI’19. ACM SIGCHI, 2019.

3.6.3 Under review at the time of writing

Carpenter, V., Sokoler, T., Møbius, N., and Overholt, D. (2018). Trækvejret: A kinetic device encouraging bodily reflection. Submitted to Tangible, Embedded, Embodied Interaction (TEI), Work-in-Progress 2019.

Carpenter, Vanessa, Khalid, Soheil, Cang, Laura. Muscle Minder: Using Twisted Actuators for Mind-Muscle Connection. Submitted to CHI'19 Late Breaking Work. ACM SIGCHI, 2019.

3.6.4 Past publications

Carpenter, V., & Olsen, M. L. (2013). Electronic sketching: Using IdemoBits as tools for synthesis in design research. Nordes, 1(5).

Pedersen, J., & Carpenter, V. (2013). Expand your design space with energy harvesting. Nordes, 1(5).

Carpenter, V. (2008). Learning in Liquid Place. IxD&A, 3, 159-162.

Brynolf, D., Carpenter, V., Hobye, M., & Larsen, H. S. (2008, September). Bodily awareness: an exploration in critical design. In Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction-Volume 2 (pp. 119-122). BCS Learning & Development Ltd.
Carpenter, V., & Hobye, M. (2008). Ladies' and Men's room mixup. In Design and Emotion Conference Dare to Desire. Hong Kong.

4

PRELUDE

4. HOW MEANINGFULNESS EVOLVED

A PRELUDE TO THE DISSERTATION

In this chapter, I provide a background of my practice-based previous works which led to my understanding of, and curiosity about meaningfulness. I move chronologically and first present an overview, then a method of design research wherein I present key projects which guide me towards the engagements created during the research period of this PhD, and the discoveries along the way.

4.1. Prelude: From Art, to Industry, to Academia - the PhD in Context

Framing my work around non-visual, tangible devices came from a diverse background of interactive art work, mainly conducted outside of academia, but with ties to academic work done later. In my Bachelor studies, I completed a program called Interactive Art & Technology at Simon Fraser University. Here, we explored how to create engaging art installations using technology. An example of this was FemBot, an interactive installation in an art gallery in Yaletown, Vancouver providing opportunity for open debate about the media portrayal of women as seen through the eyes of a mannequin. In this installation, we (Ben Volpov, Angie Yoo, Ada Wu, Jennifer Hui, Heidi Liao and myself) hoped to spark thoughtfulness about how women see themself, and how society sees them. It was a first year project, and had first year ambitions, but this spirit of sparking reflection and ultimately change, stayed with me throughout my studies. During my Master's degree at Malmö, Sweden I (and collaborators) were inspired by the book Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design (Dunne, 2005), and created two projects which will be explored in this PhD: The Ladies and Mens Room Mixup (toilet signs switching resulting in confusion and ultimately, communication and teamwork) (Carpenter and Hobye 2008) and the Critical Corset (a corset which tightens when the wearer's heart rate rises to explore

Photo: Mads Høbye

attraction and bodily awareness). Both of these explored how to challenge social norms and provoke not only reflection, but also behaviour change. I joined the Collaborative Interactive Arts Studio and floating maker platform, illutron in Copenhagen, Denmark and eventually formed my own company, GeekPhysical. At illutron, we created interactive art installations using new technology with old, recycled materials and in the case of GeekPhysical, creating interactive installations for guerilla marketing to engage people and make them reflect and act. Our ambition was to create opportunities for engagement which were initially, easy to engage with, and then (as Mads Hobye describes in his PhD examining illutron projects (Hobye, 2014)) had increasing internal complexity, offering a more in-depth experience with greater challenges the more people interacted with the installation.

Recalling my past projects, a narrative began to emerge. This narrative is about a person, entering a world where sensors are readily available, where anything can be an actuator (many of our installations resulted in fire or water explosions, much to the delight of the participants) and where any object can become magical, enchanted, as per Rose (2014) and Wright and McCarthy (2005). In this world, people can engage with objects, be playful, be challenged, question their social norms and ways of interacting with the world, reflect, and change their behaviour, even changing their life. In his work explaining the role of “The Implied Producer” - the persona in post-digital participatory culture, Søndergaard refers to the role of art: “Art is not about representation anymore, but about participation in and production of real/tangible connections and relations in an increasingly distributed and technologically motivated world.” (Søndergaard, 2012) This narrative about the participatory aspect of being playful and challenging norms and engaging in the tangible in this technological sphere is one I return to throughout this dissertation, exploring the potentials of technology and humans.

A new challenge presented itself when I was offered a position in IdemoLab, DELTA (now - FORCE Technology). In IdemoLab, we focus on experience and hardware where we aim to design the experience of technology itself, and this has become the platform upon which this PhD has been built. This PhD has been done as part of my work within IdemoLab and I have remained in my position as Technology Experience Designer during the duration of this PhD. In this position, I simultaneously recruit new startups and larger companies who are seeking to create a new device, whilst also being a technology evangelist and concurrently stating my own (and IdemoLab’s) Rule Zero repeatedly: “No technology for technology’s sake”. (Note, it has been pointed out to me that an interesting debate would be to compare this to "ars gratia artis", art for art's sake, but this is beyond the scope of this particular work). Alongside colleagues, I drove business development, helping companies to approach investors and designed a design process consisting of eight steps which move from concept, state-of-the-art analysis, early, tangible prototype and testing in context, to reliability and regulatory consideration, to using a design panel to evaluate the concept and prototype to preparing for market launch. I led companies through this process time and again, and through this, my PhD emerged.

In the Chapters 5 and 8, I will cover many of the areas which discuss these concepts but here, I am explaining how *my* particular lens was formed, and how I have experienced companies form their lens of technology and design. 'Design Thinking' as a term and a practice is only now beginning to be understood and accepted as a norm within industry. I still meet companies who haven't heard about it. And while many of the concepts I've discussed above are firmly established in academia, they are not always known, named or utilized in industry. Therefore, I will explore this in the academic sphere throughout the dissertation, however, in this chapter, I am presenting this topic of technology and participation as I have seen companies explore it.

After working with many companies over the span of 6 years as part of IdemoLab, I found that the majority of companies who I worked with are limited in their imagination of what technology can be, of what devices can be. This is not a negative assessment of them but rather a reflection of what the word "innovation" entails.

> *"Questions must be asked about what we actually need, about the way poetic moments can be intertwined with the everyday and not separated from it. At the moment, this type of design is neglected and regarded as secondary. Today, design's main purpose is still to provide new products – smaller, faster, different, better."*

From "What the hell is critical design?" (Dunne and Raby, 2001, on The New School Website)

Coming from a world of art installations where playing with water can result in a fire explosion, where touching dancers results in sound, light and of course, fire, where industrial one ton ABB robots dance in response to a human's movement, I was saddened that companies were not able to imagine technology in the same way as I did, well and truly 'outside the box' and concurrently, that their ambition to create smart products which impacted people's lives in a positive way was not necessarily being met. I designed and facilitated many ideation workshops and tangible early prototype building sessions, but the problem persisted: At the end of the day, the companies wanted something they had seen before, a wrist-worn screen, an iPad on an electric bike, a pillbox that blinked and beeped. They wanted something safe and predictable, something that would both help people and be successful from a business perspective. All of which was fair enough from their perspective. However, from my perspective, the problem was clear - what we are bringing into this world is more and more silicon encased gadgets, throw-away technologies designed for obsolescence, which are not thoroughly thought-through, tested, truly made for the person who has to live with it at the end of the day. Further, few of these employed more than an accelerometer, sensing movement and blinking or beeping, sending a notification to a smartphone as an output.

I began to give lectures, to do industrial presentations and try to show companies, designers, engineers, and everyone in between about what was possible. I showed them the creative and crazy projects we had done at illutron and GeekPhysical. I demonstrated what was possible with technology. I presented examples of on-market products which had failed consumers, to show that even good design or financial backing cannot necessarily save a product, nor make it successful. Something was missing though, it wasn't just about the success of the product, or how people adopted it. It was about participation, about how people's lives changed as a result of using this product - or not.

In the meantime, I had taken over a company I worked at for the past 10 years, Copenhagen Grotesque Burlesque. I introduce this, maybe seemingly unrelated facet of my background, to frame how I use terminology throughout this work, and how my lens of the world is crafted. Copenhagen Grotesque Burlesque is a Participatory Arts Party. Everyone who joins is expected to participate. From simply dressing up and being in character, to creating elaborate experiences and performances, everyone who joins should create something for others. *Everyone is a participant.* Designing these events and curating what people bring as participatory engagements has directly influenced how, for example, I design a medical device. Here, I imagine how to engage the elderly person who has to remember to put on a medicinal lotion as part of their morning routine. A pillbox design doesn't work here. How do I engage them, how do I make them a participant, a co-creator of this process, and eventually, how do I ensure that they feel not only empowered, but eager? Much of this is about character development, which we delve into deeply with Copenhagen Grotesque Burlesque, helping people to *become* whether through costume, performance, installation, engagement, or participation.

Bringing all these aspects together, participatory engagement, art installations using a multitude of sensors and anything as an actuator, and a deep rooted problem with the imagining of new technologies, alongside a lack of adequate consideration for the impact on people's lives led me to thinking about meaningfulness.

In Chapter 8 I explain as precisely as I can, what I mean by this and how it has emerged throughout this PhD. In this prelude, I will reiterate briefly that overall, what I mean by meaningfulness is to encounter and faciliate meaningful experiences which lead to changing one's behaviour based on reflection and engagement with a smart product.

I aim to carefully and specifically frame this PhD around consumer facing smart products, and how designing for meaningfulness within smart products is *not* always necessary but can be one way companies can create smart products with a lasting impact. The PhD explores two aspects: the physical characteristics of a smart product which might enable meaningfulness, and how companies can imagine a new smart product which creates lasting impact leading to a meaningful life.

Bernadette Jiwa in her book, "Meaningful" writes:

> "What companies and entrepreneurs sometimes forget is that the purpose of innovation is not simply to make new, improved products and services; it is to make things that are meaningful to the people who use them."

(Jiwa, 2015) installation.

5

DRIFTING

5. DRIFTING

A GENEALOGICAL APPROACH TO UNEARTHING QUALITIES OF MEANINGFULNESS

Drifting is a theoretical concept within design research which gives the researcher the freedom to be explorative in their approach of designing for interactions. Koskinen and Krogh (n.d.) describe drifting as: “The path from research to design is a form of drifting, and that there is no foolproof path that should be followed. Rather, there are many paths, and solid design outcomes may take several routes.”

It is drifting that led from interactive art installations to working with smart products to working on designing for meaningfulness. Many paths were chosen without a clear and concrete outcome in mind; and this is also the nature of the dissertation, the design artefacts developed helped to illuminate qualities of designing for meaningfulness and from this the dissertation emerges. Throughout this dissertation, learnings emerged each time an artefact went through the process of construction and deployment and each time there was a period of reflection, and drifting occured after each of these instances. Krogh, Markussen and Bang (2015) explain how “”drifting” is a quality measure as it tells the story of a designer capable of continuous learning from findings and of adjusting causes of action”. It is my hope that throughout this dissertation, it becomes clear how learnings, findings and adjustments not only from the activities within these past three years, but from the path that lead me here, contributed to a drifting towards designing for meaningfulness. Related academic works are presented in the following chapters. In this chapter, I focus on my own past work to give context as to how I arrived at the conclusion that meaningfulness was an important aspect of interaction design.

For me, it’s relevant to make two distinctions of drifting which represent pragmatic interpretations of my creative work and the theory I have encountered. I hereby call these “*Creative Drifting*” and “*Theoretical Drifting*”. Within Creative Drifting, I present three projects from each of three places which have influenced my work, illutron, GeekPhysical and IdemoLab. These projects will re-emerge throughout this dissertation acting as points of comparison. Within “Theoretical Drifting” I present and reflect on the heritage of design leading to this area of meaningfulness.

5.1 Creative Drifting

In this chapter, projects are presented from each of the major areas of my work, demonstrating how designing for meaningfulness evolved. Three projects from each illutron (Collaborative Interactive Arts Studio), GeekPhysical (my previous company, specializing in biometric social interaction) and IdemoLab (hardware meets design lab where I conducted this PhD) are presented and described in terms of concept (what it was we made), interaction scenario and outcome (a description of how people engaged with it, and briefly, what happened) a description of how this relates to designing for meaningfulness, and a description of the Manifestations of Meaningfulness, in terms of non-screen/non-visual, tangible, everyday objects, or craft. These projects are presented as a background to explain how designing for meaningfulness and these particular qualities came to exist within this PhD. The Mechanics of Meaningfulness and Manifestations of Meaningfulness will be explored and explained fully in Chapter 8.

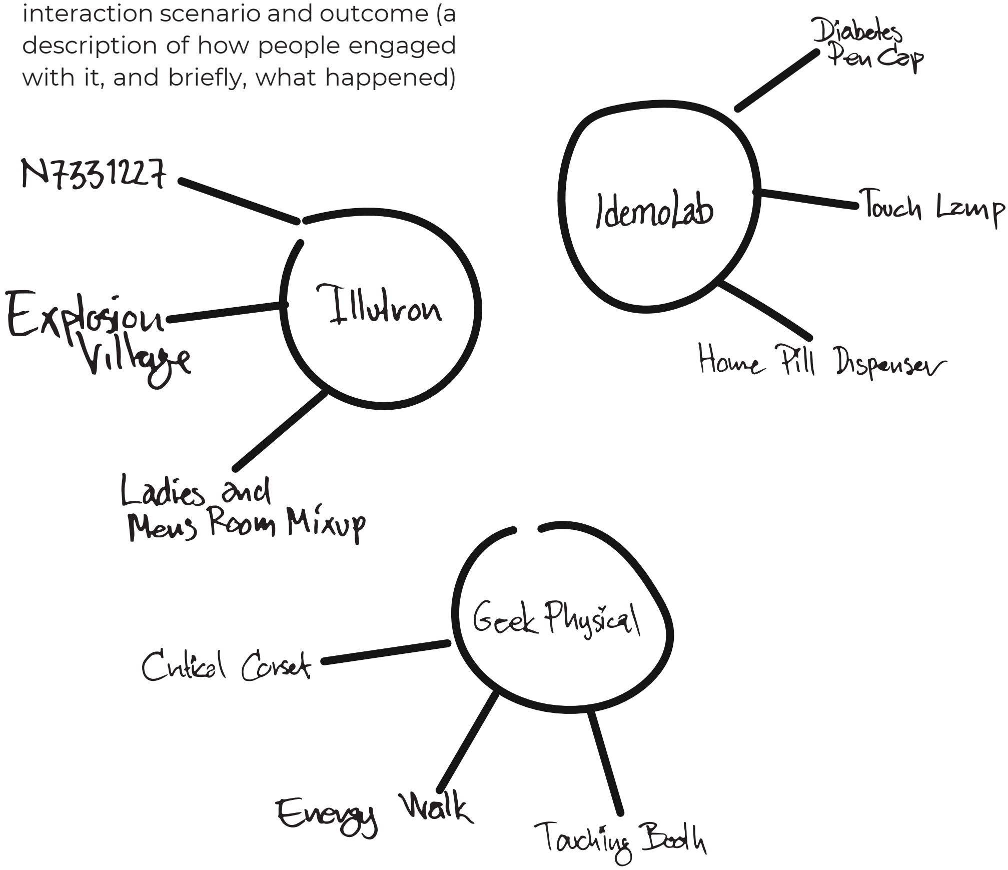
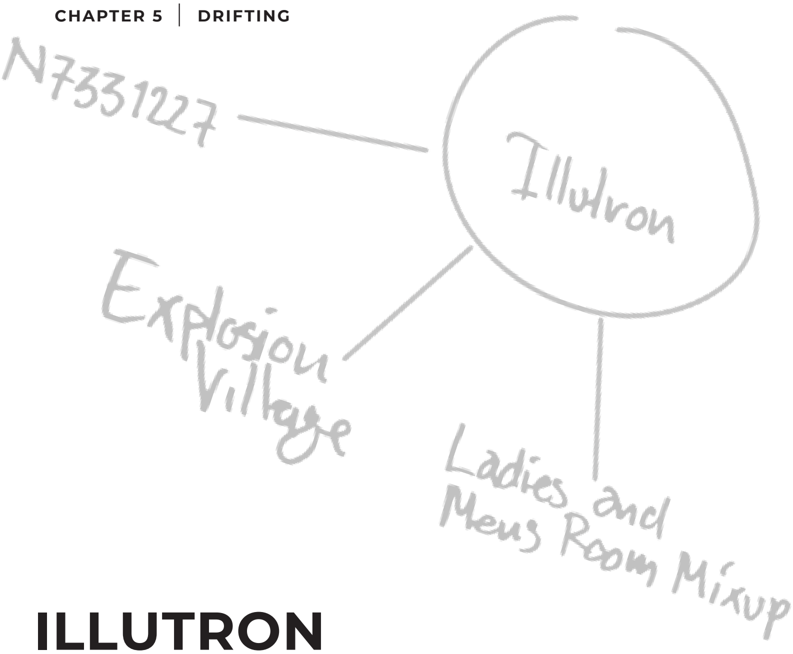


Figure 8: Three projects in each of the three domains which contribute to my lens of meaningfulness.


ILLUTRON



ILLUTRON

At illutron, the Collaborative Interactive Arts Studio, individuals and groups alike worked on small to large scale projects. 3 of the group's projects of varying size are presented here, as examples of non-visual, tangible, and embodied interaction. For each of the projects, a brief overview of concept will be provided alongside a typical interaction outcome, and how they relate to designing for meaningfulness.

Photo: Jev Olsen

LADIES AND MENS ROOM MIXUP (2007)

In a nightclub setting, we aimed to explore social norms and how to provoke communication between people. We placed LED matrices on the toilet doors with symbols for men's and ladies' toilets and every 7 times the doors opened and closed, the toilet signs switched. The women's room became the men's room and vice versa, until they switched again.

Interaction scenario and outcome

A woman walks up to the women's room, clearly indicated by the pink dress figure light up in LEDs on the door. She goes inside, and soon thereafter, a man enters the restroom, and then another. She is initially confused, but - so are the men, "what are you doing in here?" they ask, and she says, "no, what are you doing in here?" After a few rounds of this, all go out to point at the door, and are encountered by a sign which has just changed again.

Once outside, there are whispers and glances as they try to figure out what's going on, and soon they realize the game. Those who are bolder, play along with the game, and start to help people figure out which toilet to use - this quickly becomes an easy pick up line, and the games continue.

Designing for meaningfulness

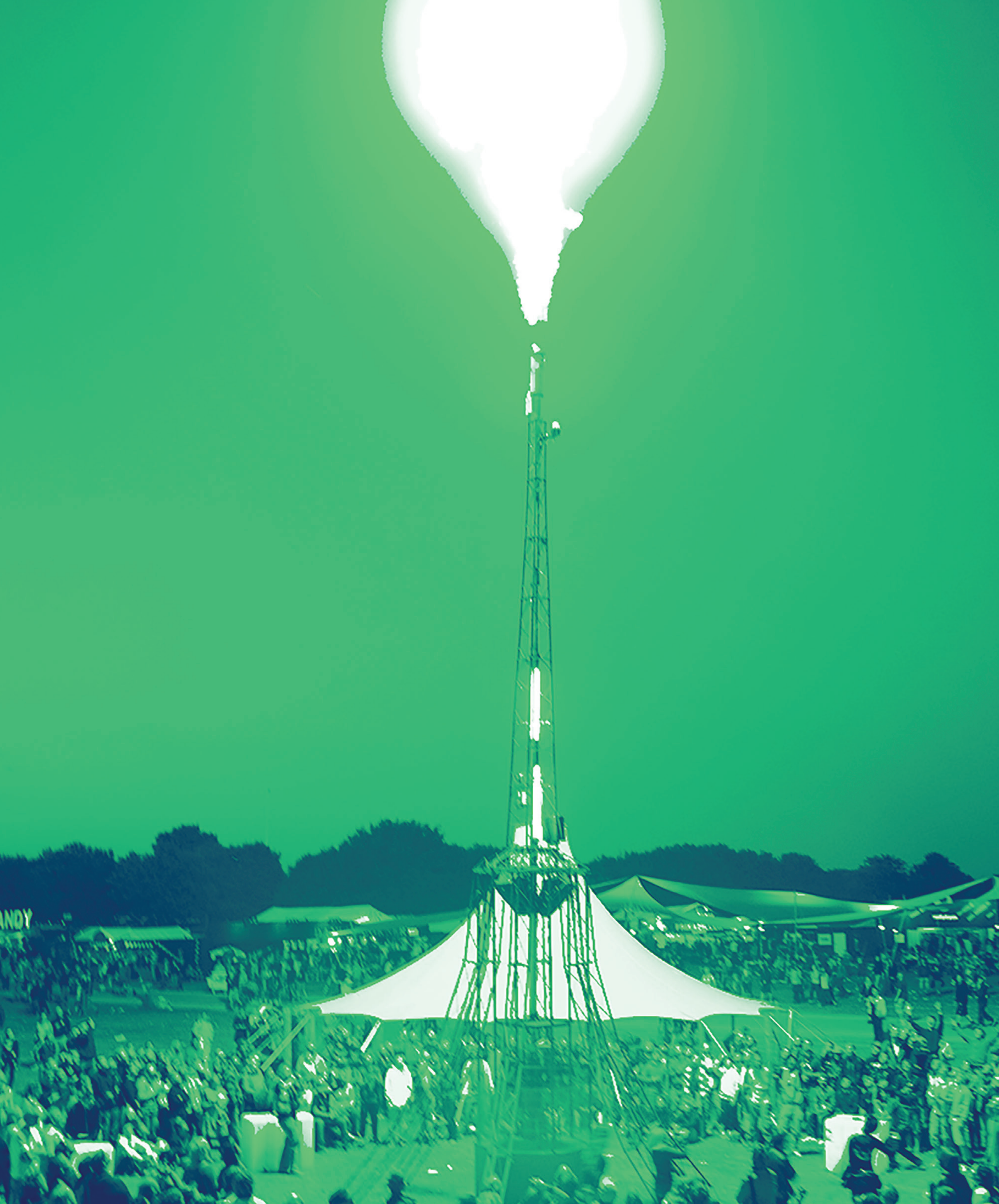
The main takeaway for designing for meaningfulness here is the gender confusion leading to re-evaluation of the situation and questioning of values and self. Especially as men entered the women's room unknowingly, there was a social taboo that had been crossed, men in the women's room. By challenging and confusing the participants, we enabled them to question the role of gender, and evaluate their role, in that moment, and throughout the rest of the night.

Manifestations of Meaningfulness

The Ladies & Men's Room Mixup featured two LED matrices, each with a symbol of a man or woman on it. Besides that, the technology was invisible. Such a simple device had a significant impact on those who encountered it.

Credits
Daniel Brynolf, Mads Hobye, Nicolas Padfield and Vanessa Carpenter. With thanks to InKonst night club.

Publication
Carpenter, V., & Hobye, M. (2008). Ladies' and Men's room mixup. In Design and Emotion Conference Dare to Desire. Hong Kong.



EXPLOSION VILLAGE (2008)

Large empty water tanks are placed in a field at Roskilde Festival, a music festival in Denmark, attracting 150,000 people. These boxes contain contact microphones and lights. As people drum on the boxes, and achieve a kind of unison, energy is built up, and represented by fluorescent tubes on a large tower. When the energy builds up enough, a fire explosion bursts from the top of the tower.

Interaction scenario and outcome

Two hundred people would gather at a time, to engage by drumming, becoming primal in nature as they did so, screaming for fire. They drummed incessantly and without much notice of their fellow drummers, hoping for a fire explosion. When the tower erupted, two hundred people celebrated, jumping, screaming and hugging one another.

Designing for meaningfulness

The experience at the Explosion Village can only be described as primal. People of all ages gave in fully to the experience, and this transcendence, this acceptance of, and aspiration towards a common goal (fire) created bonds between people, and a sense of community. They worked together, they made room for others, and they *became*, whether they became part of the group, drummers, or simply in thrall to the fire.

Manifestations of Meaningfulness

The water tanks responded to drumming by both blinking coloured lights inside and playing the sound of the drumming on a loudspeaker. People could see a build up of energy on the fluorescent lights on the tower. This was a non-visual, tangible and embodied solution. Not only did people drum, but they put their whole bodies into it, moving with the crowd, some even jumping on top of the water tanks, others using their legs or even heads to drum.

Credits
Anders Olsen, Andreas Bennetzen, Annechien Seesink, Casper Øbro, Claus Jørgensen, Daniel Brynolf, Eva Kanstrup, Frederik Hilmer Jensen, Harald Viuff, Helle Falk Jakobsen, Henrik Svarrer Larsen, Jakob Sindballe, Johannes Asker Andersen, Jonas Jongejan, Jun Philip Kamata, Karen Gamborg Knudsen, Kasper Rasmussen, Khorsed Alam, Ki Elvira Roux Fuglsang, Mads Hobye, Marc Cedenius, Mathias Vejerslev, Morten Vendelboe, Nicolas Padfield, Nikolaj Møbius, Peter Madsen, Pia Nielsen, Rikke Rasmussen, Romy Kniewel, Schack Lindemann, Simon Lausten Østergaard, Sofus Walbom Kring, Sonny Windstrup, Stig Eivind Vatne, Tanja Jørgensen, Thomas Fabian Eder, Thomas Jørgensen, Tobi Twang, Vanessa Carpenter and Vibeke Hansen.

Photo: Schack Lindemann


ASEA

N7331227 INDUSTRIAL ABB ROBOT (2009)

30 years ago, N7331227 used to grind out toilet seats. After significant reverse engineering, it became an interactive installation at Kunsthallen Brandts in Odense. Via a camera mounted on its arm, it became a curious robot, intrigued by passer-bys and hopeful that someone would draw an image, and show it to the robot, so that it might redraw the image by pressing buttons on and off to illuminate a wall of light bulbs.

Interaction scenario and outcome

In N7331227's retirement, it wants to meet new people, and pick up a new hobby, drawing. In the museum, it was playful with people, following them and if they decided to stop and say hello, it moved with them, mimicking their movements.

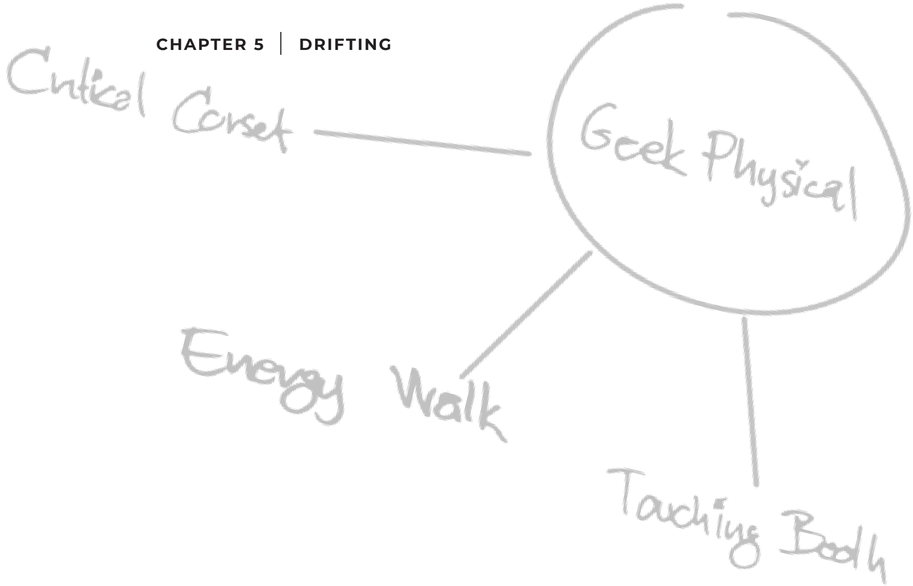
Designing for meaningfulness

N7331227 represents a shift in thinking from serious, goal-oriented, pragmatic work to playful, curious, and thoughtful interactions. In bringing N7331227 out of retirement and introducing it to new people, we were able to show them that they too could be playful, curious and daring enough to play with a one ton robot, transforming from a passer-by, to a participant.

Manifestations of Meaningfulness

There was no touchable technology with N7331227. Either you engaged with it by catching its eye, or you drew a picture with pen and paper and held it up. Either way, your body, or your drawing was the interaction modality. So while this was not a tangible experience per say (one could argue that the act of drawing might fall into this category), the lack of visible technology (besides the robot), and the surprising interaction which emerged (the robot reacting to your movement) was a way to make people aware of themselves, their actions, their reactions, and how they moved in the space.

Credits
Brian Josefsen, Eva Kanstrup, Jonas Jongejan, Mads Hobye, Nicolas Padfield, Nikolaj Møbius, Schack Lindemann, Thomas Fabian Eder and Thomas Scherrer Tangen.



GEEKPHYSICAL

GeekPhysical, a company focusing on biometric social interaction makes people say "you wouldn't believe what I did today". GeekPhysical emerged from illutron. As illutron focused on large scale interactive art created by groups of artists, GeekPhysical focused on biometrics, and guerilla marketing installations.

Photo: SparkFun Electronics

THE CRITICAL CORSET (2009)

As a person's heart rate rises, the corset tightens in an attempt to make them aware of their biometrics in a given situation. The concept originated from a curiosity about how we know we are attracted to another - before the time of quantified self health tracking wearables.

Interaction scenario and outcome

As a person's heart rate rises, the corset tightens. As it turns out, their heart rate rises repeatedly throughout the night, from dancing, drinking, and maybe from meeting that special someone. They are more aware of their sense of body as they relate to happenings around them.

Designing for meaningfulness

The Critical Corset is an example of critical self reflection. While wearing it, the wearer is hyper aware of their heart rate, and while they cannot detect the exact beats per minute, they can tell whether it is faster or slower because now they are paying attention to it. Was it because I was dancing, or was it because I was dancing with *him*?

Here we begin to see that the wearer can explore their sense of self through this critical self reflection and begin to seek out and examine their relation to what is meaningful in their experiences.

Manifestations of Meaningfulness

The corset inflates with air via a small compressor placed in a purse powered by a battery. The wearer is wearing a running heart rate monitoring band, and when the heart rate is detected to go over 70bpm, it begins to inflate.

This was a tangible experience (tightening), non-visual (focus on the body) and was invisible to others, in that they couldn't see and for the most part, were not aware of the fact that the corset was tightening, it was a personal experience (unless one was close enough to hear the compressor hidden in the purse).

Credits
Vanessa Julia Carpenter & Nikolaj "Dzl" Møbius.

THE ENERGY WALK (2016)

The walking sticks were part of an experience created for the northernmost part of Denmark, an "ethnographic installation in the landscape"[1]. This was part of a research project called Alien Energy at the IT University of Copenhagen. Researcher Laura Watts illustrated through audio storytelling, the sustainable energy futures of the area. We built custom wooden enclosures housing location-responsive audio playback technology into walking sticks. As people walk through the landscape, the story continues, depending on where they are.

Interaction scenario and outcome

A person borrows a walking stick from a local store. On the end of the walking stick is a carved circle of wood and headphones are plugged into this. The person takes the walking stick and a map and begins their journey. At points along the way, they pass symbols which indicate to them to touch the wood to the symbols and the story, narrated by Laura Watts (English) and Peter Adolphsen (Danish) continues.

Designing for meaningfulness

Energy is invisible for the most part, and in these remote locations, energy is present in everything, the waves, the wind, the light, and it's how people make their living. Creating these stories of the local energy, people could be connected to each other, going for a walk and learning something new together; they could be connected to the local area and stories, and they could critically reflect about the energy that is produced and what they use, understanding energy in a new light.

Manifestations of Meaningfulness

This project embodied all the Manifestations of Meaningfulness - the walking stick itself was hand carved from local wood from the national park. The ball which we created was a first prototype exploration of 3D CNC (Computer Numerical Control) routing wherein a smooth sphere of wood was cut with a router. This was also a form of crafting. Using the everyday form of a walking stick, a 'normal' experience was provided for people, and the entire thing had absolutely no screens involved. Finally, it was a tangible experience, picking up the walking stick, putting on the headphones and going for a walk in nature.

Credits
Laura Watts, Peter Adolphsen, Vanessa Julia Carpenter & Nikolaj "Dzl" Møbius. Created as part of the research project Alien Energy at the IT University of Copenhagen. http://sand14.com/energy-walk/ .

1 *As described on https://sand14.com/energy-walk/*

THE TOUCHING BOOTH (2011)

Photo booth meets kissing booth in this interactive installation wherein two people sit in chairs, and as they touch, a photo is taken. Originally created for an art and hacker festival in Nantes, France at a nightclub, the installation has been used at industry conferences, events, weddings, and happenings throughout Europe.

Interaction scenario and outcome

Two people sit in two chairs, which are situated in a box, outlined by tape on the floor. Projected on the wall is an image of two people touching as they sit in those two chairs. People shake hands, then touch a hand upon a knee, some fist-bump, others stroke hair, some hug, awkwardly, between the chairs. Each time they touch, a photo is taken and projected on the main screen, for all to see.

Designing for meaningfulness

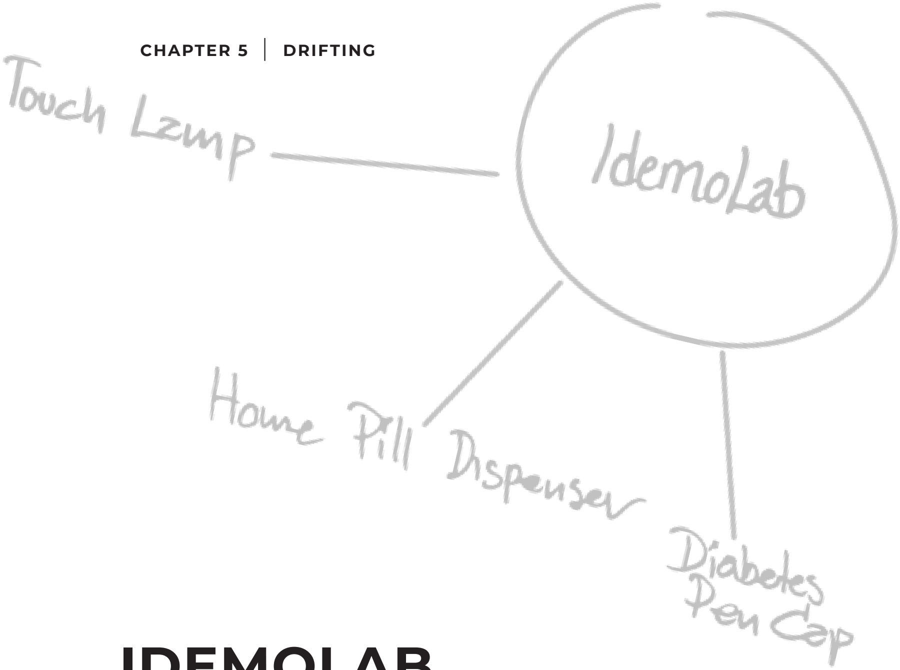
In the first instance at an arts festival and a night club, people were playful and happy to try out new things. Even so, it could be seen that some were uncomfortable with touch. Two men sat down together and shook hands, then experimented with different types of 'cool' handshakes and fist bumps - but never anything more personal or intimate. When at industry conferences, people shake hands, but rarely do more, only touching the most socially acceptable places (hand, knee, shoulder) during an industry event. In each of these scenarios we witnessed that people were eager yet shy to explore touch, they wanted to try the thing but in different environments and with different partners, would be more or less willing to touch.

Manifestations of Meaningfulness

Two chairs are placed facing each other and contained by a box on the floor outlined by tape. Each chair had one wire taped to a metal leg. As two people touched, they completed an electric circuit, activating the camera. Here, tangible interaction between people resulted in photos.

Credits
Vanessa Julia Carpenter & Nikolaj "Dzl" Møbius.


On Foot Enclosure
Sore Score
MoodMeter
Building with Bits



IDEMOLAB

With experts in both hardware engineering and interaction design, and those who cross over in both domains, IdemoLab has a focus on user centred design, developing concepts into early, functional mockups and evaluating them in context with users, before progressing to a design panel and regulatory and reliability pre-evaluations.

Photo: Mikkel Leth Olsen

HOME PILL DISPENSER (2016)

This project asked the question of how we might enable the elderly who have to take upwards of 25 pills per day to receive their daily medication via a dispenser which is refilled every 14 days. Months of research were done to create a series of mockups which were evaluated with the elderly participants in their homes.

Interaction scenario and outcome

A person, living alone, takes many pills throughout the day and before bed. In addition to this, they must weigh themselves during the week and apply a topical cream daily. They still have good memory function but it is difficult to remember all these pills, times of dosing and order of pills. Normally, a nurse comes to visit them once a day to help them take these pills but due to budget cuts, they are given a pill dispensing system which is designed as a box, easily sitting on their countertop or in a cupboard.

Designing for meaningfulness

This project enabled the elderly participants to take their medication on their own. It enabled the municipality to reduce the number of health related issues as the elderly forgot their medication or the tired nurses dispensed the medication incorrectly. However, if implemented, it would remove a vital part of the elderly participant's routine - the social time with the nurse. This social interaction was a major aspect of what made their lives meaningful, looking forward to the visit, tidying their homes and preparing coffee for the nurses.

Manifestations of Meaningfulness

The pill dispenser, in its early prototype form, was first a small IKEA box, with a hole cut in it, as you placed a coffee cup under it, it would dispense medication - due to an input from elderly participants that often they took out their pills, got a cup of coffee or water, and forgot to take the pills, so if the pills were in the cup in the first place, they might remember. In later iterations, it became a large box, with a non-screen display which allowed icons to shine through, with a lever which the participant could pull to dispense medication into a cup. The lever was part of an investigation on how to reduce the number of regulatory considerations that were required for such a device.

Credits
IdemoLab including Morten Georg Jensen, Vanessa Julia Carpenter and previous work done by Mikkel Leth Olsen which informed this project.

Other collaboration partners included Bornholms Regions Kommune, Pharmakon, MedicPen and KMD. This work was funded by the foundation LevVel.

THE TOUCH LAMP (2014)

A lamp which is a lifestyle accessory, is portable, and is a Bluetooth speaker. It can be used for work such as adjusting the temperature of light, for social situations, such as at the beach, or in the backyard, BBQ-ing, or as a bedside lamp and alarm.

Interaction scenario and outcome

Waking up to a soft light, and their favourite tune, a person caresses the lamp beside them to quiet it and not wake their sleeping partner. Throughout their day, the lamp is their companion, playing music, providing different styles of lighting and eventually acting as a gentle candle, until they go to sleep again.

Designing for meaningfulness

This was an investigation into interaction scenarios of such a device and how the technology could be developed to be as intuitive and non-screen as possible, requiring all interaction to be on the lamp itself.

Our aim was to create a companion device which is with you throughout your day when you are at home or out being recreational or social. Further, it should be a tool in that it simply works, the technology and interaction disappears into natural movements. This was an exploration into how to create value over function.

Manifestations of Meaningfulness

We wanted to find out which technologies were necessary to have interaction happen on the lamp itself, using soft buttons, and capacitive touch to change music and lighting, and Neo-Pixel LEDs to adjust light temperature and responsiveness.

We turned to an acoustics expert to design a speaker which would work for the small speaker format, and to allow for a water and sand proof design while still providing good sound. This was an exploratory, experimental project which helped to inform this PhD.

Credits
IdemoLab including Søren Gerluf Sørensen, Morten Georg Jensen, Dušan Vučković, Mikkel Leth Olsen, Morten Wagner, and Vanessa Julia Carpenter, SenseLab & Product Design and Innovation Consultancy RSW (https://www.rudolphschellingwebermann.com/)

Photo: Søren Gerluf Sørensen


.time
"By clearly showing the time since their last injection,
the person with diabetes has a record of when that was."
www.nicodesign.dk e-mail: nicodesign@adr.dk
Drejebog D-time (draft)
CONFIDENTIAL

DIABETES PEN CAP (D-TIME) (2015)

This project began from an analysis of current on-market products which have some failings, such as tiny, difficult to read displays. The unit we developed registers only when injection is completed and the interface is simple one pushes down on their pen when injecting, and D-Time activates. Finally, it is compatible with most diabetes pens on the market.

Interaction scenario and outcome

A person, in their twenties comes home from work after being at school. They take an injection and prepare dinner, watching a movie and eventually falling asleep. Waking up four hours later, they can't remember whether or not they took their pre-dinner shot, as they were exhausted when they came home. They check their pen and see the last injection was five hours ago, just before they made dinner. Relieved, they go back to sleep and wake up refreshed.

Designing for meaningfulness

D-Time focuses on value over function. It focuses on just one thing - when did you last inject? Our workshops leading to the development of this product helped to determine this as the single most important piece of information for our participants. It focuses on personal development and lends to moments of meaningfulness in everyday life. It was meaningful to the participants in our workshop to be able to lead normal lives, working, going to school, cooking dinner for their families, travelling, and enjoying a movie after a long day, instead of trying to figure out when their last injection was.

Manifestations of Meaningfulness

The display developed for D-Time was an e-ink screen to save battery and a special font was designed to be easily readable and as large as possible given the small screen real estate. The timer was triggered by the pen being pressed down and was developed to work with a variety of insulin pens. The motto of this project, from Nico-Design was "No new buttons, no extra work, just more security.". This is an important aspect of the Manifestations of Meaningfulness of designing for meaningfulness, that it simply works without excess interaction, button pressing, notification checking or otherwise, one glance at the display gives all the necessary information.

Credits
IdemoLab including Morten Georg Jensen, Dušan Vučković and Vanessa Julia Carpenter, and Nicolas Nicolaou and the NicoDesign team (http://www.nicodesign.dk/)

5.2 Theoretical Drifting

FROM PHYSICAL COMPUTING TO MEANINGFULNESS

HCI and interaction design has grown significantly since its inception, and again since interaction design became more well established. In this time, the types of work emerging have ranged from a strictly physical computing aspect of computer/ machine and human to embracing values of philosophy and exploring the impact of design in relation to interactive technologies.

Here, I present 12 topics in design research as a mapping of this domain. By forming an initial mapping of these areas, I can begin to point to the opportunity for designing for meaningfulness. These areas include:

1. Physical Computing
2. Tangible Interaction
3. Experience Design
4. Everyday objects
5. Presence
6. Well-being
7. Happiness
8. Authenticity
9. Positive Design
10. Hedonic Qualities
11. Eudaimonia
12. Reflection

Each topic is presented briefly as an introduction, and then expanded upon and referred to throughout this dissertation.

Physical computing

Tom Igoe and Dan O'Sullivan wrote the book on Physical Computing (2004) and describe humans as seen from the perspective of a computer, as having primarily visual and auditory senses. I've used

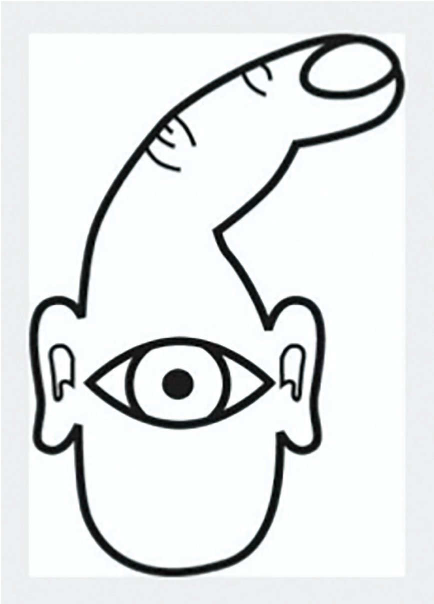


Figure 9: How computers see us now - from O'Sullivan and Igoe, 2004.

this image (Figure 9) in countless presentations since it demonstrates so well what physical computing is about, connecting the real world (including people) to computers and computers to the real world. There is clearly so much more that humans can sense (and that sensors can sense) but for many, this is human-computer interaction - a finger, an eye, and ears - aka a keyboard/touch interface, screen and sound. Physical computing has grown tremendously in recent years, and through the development of platforms and communities such as Arduino[1], people are able to experience and explore the possibilities with sensors and actuators on their own, for a low cost, both in terms of time and money.

Tangible interaction

Moving from the purely physical quality of physical computing, we approach theories of physical computing such as tangible interaction, which is more concerned with designing the interaction itself as opposed to the physical aspect alone. It focuses on physical embodiment, which Dourish (2004) relates to social interaction and how we exist in the world, as experienced through our bodies (phenomenology) (Kozel, 2007). Embodiment is a core focus and from this, experience centred design with a focus on the bodily experience has been prominent within HCI. McCarthy & Wright (2004) describe thinking about "technology as experience", providing an early framework for this way of thinking and designing, which is echoed in somaesthetic design research such as that by Höök et al. (2018) who describe the "felt dimension". Felt experiences have become more prominent, with research into how the interaction feels on a physical and emotional level, and what it results in, as technology acts on or with the body. (Núñez and Loke, 2017).

Experience design

When considering technology as experience (McCarthy & Wright, 2004) we look past physical computing and using the lessons learned from tangible interaction, begin to consider how to design for these experiences. Whether the user is acting on the technology or the technology on the user or, there is a symbiosis of the two, this experience can be designed *for*. It cannot be said that we as designers can predict exactly what someone's experience might be, rather we can design for certain circumstances to exist in which a particular outcome is anticipated. Wright and McCarthy explain: "...we cannot design an experience but that, with a sensitive and skilled way of seeing user experience, we might be able to design for an experience." (2005). In this light, much of the research presented in this dissertation points towards what meaningfulness *might* entail, though none, not even the so-called user can say for sure what will be meaningful until they experience it and reflect on it.

Diefenbach, Kolb and Hassenzahl (2014) offer a review of 151 publications which are aiming to design for hedonic experiences, indicating a significant research in *designing for* an intended experience. Various formulations of this 'designing for' schema exist, such as Hassenzahl et al. (2013) who describe designing for happiness and moments of pleasure wherein they describe two aspects

1 *Arduino is a open-source electronics platform. https://www.arduino.cc/*

of experience design: material and experience: "The material is the tangible arrangement of technology; the experiences are the meaningful, positive moments created through interacting with this arrangement"

Everyday objects

In the scope of this dissertation, I am examining predominantly everyday objects in the form of consumer facing smart products. I am not looking to industrial IoT applications where a system of machines is being monitored. Instead, I am looking at personal, or interpersonal experiences with devices. Thus, there is a distinct focus on everyday objects. In "The Aesthetics of Everyday Objects" (2015) Milling presents a phenomenological approach, in that the "aesthetics of an everyday object is co-constitutive of its experienced meaning" and is "deeply anchored in our everyday engagement with objects".

Aligning with Senger and Gavers, who explain that the intentions of the designer are not always the outcome experienced by the user, and that the designer might aim for multiple interpretations of a design (Sengers and Gaver, 2006), Milling states "the experience design-process is co-creative, since by interacting with an everyday object, the user appropriates and co-defines the meaning of the object on a pre-reflective, embodied level" (Milling, 2015).

As designers, we are designing experiences. If we aim to design for meaningfulness, we must design for multiple interpretations (see Chapter 8: Meaningfulness in Everyday Life) as per Senger and Gavers, and we expect that the user appropriates and co-defines what is meaningful to them. Wakkary et al. present a similar approach with their "thing-centred-design" (2017) where they explain how we experience the world is through the everyday objects around us, and that "we simultaneously cannot understand what it is to be a thing, yet we would not be able to function in or comprehend our lives without things."

Presence

Following everyday objects is the aspect of the presence of these objects in our lives. Hallnås and Redström introduce *presence* as they explore the expressions of everyday things (2002). They describe everyday objects as related to existential descriptions of meaning in people's lives. They highlight that "when computer systems change from being tools for specific use to everyday things present in our lives, we have to change focus from design for efficient use to design for meaningful presence".

This aspect of *meaningful* presence is of particular note, and Hallnås and Redström extend this to objects having an *expression-identity*, the properties of the expression which define the presence of the object. This exploration of presence is similar to some of the Mechanics of Meaningfulness I present later (Chapter 8), exploring how everyday objects and our interaction with them forms our meaningful experiences and thus, designing for these interactions, with objects of presence, which hold existential value is of relevance.

Well-being

Designing for well-being is described as designing objects in a particular context for an activity which enhances well-being (Diefenbach et al., 2017). Well-being can refer to many aspects of life, from physical to mental health, to goals of self-fulfillment (Bentley et al., 2013). Diefenbach et al. point to objects as the starting point to design for "more need fulfilment and ultimately well-being" (Diefenbach et al., 2017).

Happiness

Designing for happiness means "designing intangible experiences fueled by need fulfillment" (Hassenzahl et al., 2013) and is directly related to positive experience, which according to Hassenzahl et al., can be boiled down to six needs: "autonomy, competence, relatedness, popularity, stimulation, and security" (see Hassenzahl et al., 2013 for a full breakdown of these qualities). Hassenzahl explains that these are not the only needs, but do contribute to a sense of positivity and therefore, happiness.

Authenticity

Su and Stolterman (2016) similarly present designing for authenticity, and address the issue of subjectivity in designing for happiness, positivity and authenticity, explaining how designs which "thwart any consistent interpretation, for example, are ways to give the user's own interpretations equal footing". They explain how authentic interactions with technology are complex and that designing for authenticity might "allow us to understand the ways in which we try our best to live fulfilling and worthwhile lives with technology.".

Positive design

In their work on positive design, Desmet and Pohlmeyer describe positive design as having three facets: "design for virtue", "design for pleasure" and "design for personal significance" and describe positive design as the centre point of these three facets, "the intersection where people flourish" (Desmet and Pohlmeyer, 2013). They ask "How can design increase happiness and support people's efforts to lead full and satisfying lives?" The cross-over between happiness, well-being and eudaimonia (flourishing) is significant within this domain.

Hedonic qualities

In an extensive literature review conducted by Diefenbach, Kolb and Hassenzahl (2014), hedonic qualities were described as experiential values, typically beginning with a 'feeling' of some sort: surprise, motivation, pleasure, or a as an adjective: exciting, surprising, interesting, or impressive. In the work they reviewed, hedonic qualities were often contrasted against pragmatic qualities of usefulness and again referred back to how hedonic qualities might contribute to a more fulfilling experience than simply a useful one. In introducing eudaimonia and reflection, a deeper investigation is presented, as we move closer to a description of meaningfulness.

Eudaimonia

Human flourishing has been extensively described in the positive design space by Desmet and Pohlmeyer (Desmet and Pohlmeyer, 2013) and more recently, Huta and Ryan contrast eudaimonia against hedonia, describing eudaimonia as "seeking to use and develop the best in oneself, in line with one's deeper principles" and hedonia as "well-being is achieved through the pursuit of pleasure, enjoyment, and comfort" (Huta and Ryan, 2010).

More recently, Mekler and Hornbaek (2018) re-examine this comparison through a literature review and emphasize that eudaimonia is significantly influenced by fulfilment, as bettering oneself requires fulfilling some objective and that “when users engaged with interactive technology striving for eudaimonia, they felt confident, determined and focused, but also more introspective.” They also highlighted that eudaimonic experiences usually “remain important in the future” and that these experiences usually supported personal goals. (Mekler and Hornbæk, 2018).

Light, Powell and Shklovski discuss the significance and importance of designing for human flourishing in relation to the state of the world today (2017). This is a reappearing topic throughout this dissertation and this current chapter serves only to introduce this topic. A fuller introduction to both eudaimonia and hedonia can be read in Huta (2016) where an overview is provided. Zimmerman (2009) describes designing for the self and uses a similar research through design method to create a series of sketches, wherein his goal with these is ”helping people become the person they desire to be through their product interactions.”. This designing for the future self ties in closely to eudaimonia and meaningfulness, and Zimmerman approaches this from a perspective of product attachment, explaining how

> “People invest psychic energy into their possessions, developing attachment through repeated use as they engage in the activities that give their lives meaning.”

(Zimmerman, 2009).

This is especially relevant later in this dissertation as I introduce the three takeaways, namely the link of person-to-self and identity.

Reflection

Reflection in HCI is a common topic, ranging from Fleck and Fitzpatrick who ask "What reflective behaviours do you want to encourage? Which technologies and techniques can support these behaviours?" (Fleck and Fitzpatrick, 2010) to Mols, Hoven and Eggen (2016, February) and (2016, October), who are concerned with an everyday reflection, using technology to provoke or mediate that practice. Reflection in the everyday is of particular interest to this dissertation as I believe the ongoing reflective practice has the potential to lead to to a meaningful life through facilitation of personal growth. Mols et al. are of particular interest due to their work with designing physical, tangible devices to facilitate reflection. This is in line with the ambition of this dissertation, to explore which Manifestations of Meaningfulness might enable meaningfulness to be explored. Mols et al. present a series of prototypes (Mols, Hoven and Eggen, 2017) including "Balance", a scale balanced on a point, with one side being 'positive' and the other 'negative. Prompted at the end of each day, the user records a message to the device about how their day was, which either tilts the positive or the negative side downwards (heavier). In this way, it is a reminder of their general life balance, represented by a beautiful object in the home. Mols et al. discuss the importance of presence, how the object in the home, in view of the user plays an important role, that of triggering reflection. This aspect of triggering reflection will come into play during the engagements.

Although reflective practice alone is of interest, reflection has been shown to impact behaviour change (Ploderer et al., 2014) and triggering reflection is of particular interest since has both aspects of physicality and materiality, as well as being action focused. Ghajargar and Wiberg in a recent article examine reflection in HCI and explain what is missing:

> *"The ability of smart artifacts to stimulate human reflective behaviour and to evoke thoughts in users is still relatively unexplored. Even though, it is assumed that smart devices can naturally evoke such behaviour by providing feedback and informing users, this phenomenon should be more fully explored. Especially what is relatively unexplored is the role of the forms - physicality and materiality of a smart object to evoke reflection. Such self-reflection, focusing on personal informatics, has been evoked primarily through data visualization and personal images and videos on mobile apps, websites, displays on wearable devices, and environmental installations".*
> (Ghajagar and Wiberg, 2018)

It is the intention that this dissertation contributes towards exploring the phenomenon of how smart products can "stimulate human reflective behaviour and to evoke thoughts in users" via an exploration of the the roles of physicality and materiality of a smart object. Importantly, I am interested in not only provoking *thoughts* in users, but **action and behaviour change** which leads towards meaningfulness in life.

Meaningfulness

Although each of the above areas implicity discusses meaningfulness, none *explicitly* delve into what meaningfulness might be or how we might design for it.

I am interested in meaningfulness as it facilitates **people-to-people connection, people-to-sense of self, and a person-to-sense of time**.

Many of the topics just presented do point to aspects of this, whether it be well-being for the self, or positive design for the significance, or authenticity and reflection for the aspect of critical thinking. However, I still believe there is a gap in academic research in this area and so, following, I present others who have explicitly mentioned designing for meaningfulness.

Many researchers introduce aspects of meaningfulness in their work. Ghellal, in her 2017 dissertation entitled “The Interpretative Role of an Experiencer” (Ghellal, 2017) has the subtitle “How to Design for Meaningful Transmedia Experiences by Contrasting Ambiguous Vs. Prescribed Qualities”. Here, she provides an overview of personal meaning making and concludes that there is “no consensus regarding what makes an experience meaningful”.

Ghellal references, as I have, Hassendahl’s explanation of experience as being personally significant (Hassendahl, 2013) and then moves on to explore qualities of ambiguity and prescribed qualities which she uses to design meaningful experiences. She argues that the contrast between ambiguous qualities and prescribed qualities is where the experiencer can find meaning. It is beyond the scope of this dissertation to delve into these qualities, and they can be found in Ghellal, 2017, however, it can be said that this aspect of *ambiguity* is present within my engagements. For example, the Electronic Kintsugi presented later in the engagements, does not offer a prescribed experience, instead it is open to use and interpretation, and is an object with a non-defined purpose (Carpenter, Møbius, Willis and Overholt, 2018). This aspect of openness is one aspect of designing for meaningfulness which is quite relevant for the definition I present for meaningfulness.

Ghellal’s research describes ambiguity as a way of making meaning and this phrase, “meaning making” can return complicated scholarly results as a search phrase, with everything from how immigrants come to make sense of their new homes (Allard, 2016) to how to interpret what people mean in corporate reports (Katzenberg and McDermott, 1994) to how museum visitors create their own meaning as they interpret interactive art works: “The sequence was derived from the different phases Narcissus went through according to Ovid’s Metamorphoses. This meaning was not, however, imposed on the user. Instead, each user was encouraged to come up with her own interpretation.” (Otitoju and Harrison, 2008). In this excerpt, Otitoju and Harrison refer to the interpretation, not the *meaningfulness* of the experience. They refer to what the artwork *meant* to the person. In another work, while describing an interactive water park for children, Parés, Carreras, and Durany (2005) describe: “The users’ actions must be placed at the center of the design and the meaning must be generated by making the users live the concepts.” wherein the users (the children in this case) must engage with other children by holding hands in a circle to meet requirements by a computer vision system which then presents water jets as reactions to their interaction. The meaning is generated by the users, but what this meaning is, is never explicitly explained though they do point to new social interactions and non-invasive interaction scenarios.

These examples demonstrate a complicated problem of language: what is it to mean, and to have something meaningful, or for it to invoke a sense of meaningfulness?

At this point in the dissertation, it would not make sense to delve into this, as I have not yet fully defined the aspects of meaningfulness which will be conveyed throughout this dissertation, and especially in Chapter 8 and in Chapter 10: Discussion, under “Limitations”.
Huta does delve into the distinction by comparing and contrasting terms in an overview of eudaimonic and hedonic comparisons however this foray into psychology is beyond the scope of this dissertation and can be read further in Huta, 2016. Looking into Huta’s more recent work (2017), there is a useful framework for understanding meaningfulness which is written in the domain of psychology and can be applied to HCI:

1. meaning as an orientation—that is, caring about the big picture, seeking ways to make a contribution;
2. meaning as a behavior—for example, doing volunteer work, donating blood;
3. meaning as an experience—for example, feeling that an activity of yours was valuable and important; and
4. meaning as functioning—for example, achieving a realistic conceptual framework for making sense of life events.

Within my research, I have maintained an ambition of developing smart products which enable a meaningful experience “feeling that an activity of yours was valuable and important” (Huta, 2017) and which eventually, cater to the bigger picture, as Huta explains, meaning as an orientation. It is in the crossover of these two where I find my working definition of meaningfulness and I return to Huta’s work in the workshops done with companies as explored in Chapter 7.

Huta furthermore differentiates between pleasantness and meaningfulness, explaining:

> "pleasant experiences are more about valence, degree of positivity, feeling good, and visceral satisfaction. Meaningful experiences are more about congruence, connectedness, context, refinement, heightened awareness, and value-based gratification."

(Huta, 2017)

In terms of my perspective, this makes sense, as the 'meaningfulness' I have focused on centres around critical thinking rather than simply satisfaction.

Outside of academic research, a conceptual product analysis tool, "Better Things" was built and deployed.[2] . Better things is a standard and a certification system for connected products created by Noam Zomerfeld. Noam is interested in how to create connected devices which are more well thought through, considering aspects including:

- Technological opportunities: Utilization of capabilities that are unique to Connected objects.
- Context: How well this product integrates in the lives of the persons using it.
- Interusability: The operation of the product in the larger ecosystem of connected things.
- Privacy: The application of privacy measures in the product, ecosystem and company.
- Meaning & Purpose: The function, contribution and significance of the product.
- Health & Safety: The product's effect on the health and safety of those who use it.
- Community: The effect of the product on the community in which it resides.
- Cost & Access: Availability and cost-effectiveness.
- Sustainability: Design for maintenance, upgradeability and eco-friendliness.

Part of this is to evaluate aspects of meaningfulness in connected products. The questions Noam asks companies about meaningfulness can be seen in Appendix 1 as they have been used in one of the workshops conducted for this research. These questions address some interesting aspects such as wonder, art, beauty, and also relates back to eudaimonia, asking "how does it make me a better person?".

Also from an industry facing perspective, Verganti (2017) presents his work "Overcrowded: Designing Meaningful Products in a World Awash with Ideas" which speaks to

2 *(http://betterthin.gs/)*

the **why** of what we are creating. He emphasizes a focus on a "new *how* to the same *why*" He points to the value-based aspects of products such as identity, and emphasizes their role in meaning-making. Further, Verganti emphasizes the need for criticism of concepts to reach radical innovation (Dell'Era, Altuna and Verganti, 2018).

In Overcrowded, Verganti focuses on the innovation process he designed for creating better value-based products and introduces three aspects of meaning: functional, symbolic and emotional (generating value) (Verganti, 2017). Verganti's model is a useful way to deconstruct products or services to extract the function, symbolism and emotional value and can be seen as a good example of creating new understandings of a product or service. Dell'Era, Altuna and Verganti explain how the meaning of a bicycle changes from being a method of transportation to being a city sensor, in the case of the Copenhagen Wheel (which turns an ordinary bicycle into an e-bike). They explain how the meaning of the product changes: "The technology allowed developing a new concept that changes how citizens envision a bicycle, from a bicycle as a means of transport to a bicycle as a city sensor; the semantic shift is evident". (Dell'Era, Altuna and Verganti, 2018). This change in meaning does result in many of the qualities which I am interested in with regards to Designing for Meaningfulness. For example, the shift in thinking about a product might elicit emotional considerations and changes in perception about how one thinks about transportation, or cities, or attachment to bicycles as transportation devices as in the previous example. However, what Verganti presents is mainly focused on a shift in meaning in terms of language, and does not follow the same aim of my work, which is to explore the factors which might enable meaningful experiences from the perspective of people-to-people, people-to-sense of self and people-to-time. I do not aim to necessarily define a shift in the meaning of a product.

In another domain, jewellery design (which becomes relevant for Fibo, one of the engagements designed by jewellery design students) Ahde-Deal writes about how jewellery is meaningful to the women who possess it. She describes how it invokes memories, represents friendships and familial bonds, acts as an object of power, providing for example, strength, and overall, is extremely significant to the people possessing it. (Ahde-Deal, 2013). This work was particularly inspirational to my own work as it was one of the first works I read about meaningfulness and I understood how *significance* can be an aspect of meaningfulness. These jewellery pieces are significant to those who possess them and it is through this significance that they gain the title of meaningfulness.
Ahde-Deal also presented how these jewellery pieces reflected interpersonal relationships or reflection with the self and presented many cases wherein the women

would present how they had critically reflected about their jewellery pieces, such as when one described how she never wears a piece and rarely looks at it but when she does look at it, it invokes specific memories and emotions. These stories helped to inform how I might approach meaningfulness on a human level.

Despite encountering many articles referencing meaning-making, I have not (yet) encountered the one which closely describes my lens of meaningfulness. Somewhat closer to my lens is another work about museum artefacts and emotions wherein Alelis, Bobrowicz, and Ang (2013) explain “Similarly, research shows that an object does not have one inherent meaning; rather, it is an individual who applies meaning to it based on personal connections made through memories, culture, and beliefs [6].” continuing, “Falk and Dierking observed that “the dominant motivation for humans is meaning-making” and as such, recommend that museums combine emotion with learning into their exhibits [8].” (their references in square brackets). This resonates with the aspect of eudaimonia, humans seeking to make meaning in their lives, and also experience design, how people construct their own experiences. I acknowledge that there are likely many more authors who have referenced meaning making who I have possibly not yet encountered. I see this chapter as serving to introduce the concept and of meaning making, and then refocusing on meaningfulness as a term which I aim to explore.

Researchers also point towards meaningfulness as a goal of UX such as Anderson (2011) who presents the diagram in Figure 10.

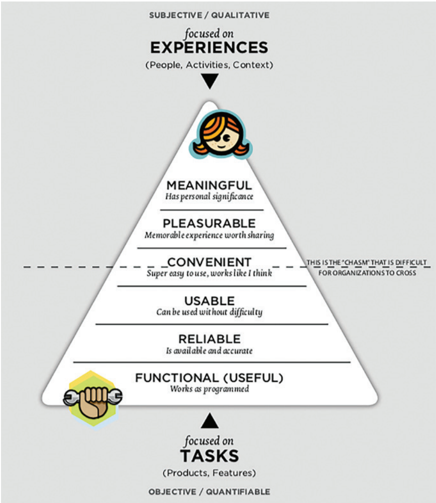


Figure 10: User Experience Hierarchy of Needs model (Anderson, 2011)

Anderson is mainly speaking about the emotional and aesthetic values of products and services, and includes meaningfulness at the apex of the pyramid, again stating that “meaning is personal and subjective” and describes the pyramid as:

> *“The challenge of this model is this: if you want to truly create a revolutionary product, you have to shift your thinking from a bottom- up task focus (which will only get you so far) to a top-down focus that starts with the experience you want people to have. By approaching things from this perspective, we see a host of new*

> *ideas, not to mention better ways to implement ideas that have been around for a while."*
> (Anderson, 2011, p. 13)

Tan and Chow (2017) reference designing for meaningfulness in the title of their paper: “Facilitating Meaningful Experience with Ambient Media”. They explain that they are interested in “the mechanism between embodied engagement and creating meaningful experience in the context of ambient media”. They look to embodiment and affordances as important aspects of their work, and present a model for embodied engagement. However, they don’t seem to return to the concept of meaningfulness beyond a tightly coupled experience between body, social, and interactive technology, and summarize: “In summary, the findings show that meaningful experience relies on the extent to which the ambient media work continuously and actively engages audience in embodied interactions, and designing the relation between input of motor action and output sensory perception is central for embodied engagement.” I agree with this tight coupling which Larsen (2017) also describes when working with embodied interaction, and that it should actively engage participants (as my preferred term to audience). However, the focus of their work seems to be on the embodied engagement rather than the meaningful experience. This does speak to the Manifestations of Meaningfulness I present later in this dissertation, as embodiment is an important aspect for this work, however I am not focused on embodiment in ambient media, rather I am focused on embodiment through engaging with tangible smart products.

In another work, Linde and Dahlgren (2003) describe socially meaningful engagements, and again, focus on the design space for social interactions and highlight the importance of physical installations for narrative rather than describing what they mean by meaningfulness. However, by indicating that physical installations are important becomes relevant for the ‘tangible’ aspect of the Manifestations of Meaningfulness which I present later. In a completely different context, Abrahamson (2008) in their article “Embodied design: constructing means for constructing meaning” discuss how to design the teaching of mathematical probability via “opportunities for students to construct meaning through juxtaposing theoretical and empirical artifacts” - in this case, playing with marbles to explore the probably of colour combinations. This again speaks to the aspect of embodied interaction and also demonstrates how meaning can be defined, in this case, the *understanding* that students gain of how probability works.

In a paper which influenced the early aspects of this PhD, Jung et al. (2011) describes *meaning*, not meaning*fulness* though it seems to be implied. This is also my interpretation, the difference between meaning and meaningfulness as distinct in some cases - as described previously, the meaning of something versus the meaningfulness (*significance* - to put it simply) of something else. Jung et al. describe how a painting of a child reminds the owner of that child, and therefore there is meaning in that object:

> *"The meaning of an object can only be ascertained by linking it with something of value, and something of value can gain meaning by being linked to something else of value. What really makes the difference is the nature of the linkage."*
> Jung et al. (2011)

Early in this dissertation, I presented those linkages in the case of Fibo: the link between partner and baby, between partner and mother, between partner and society. This relational linkage is an important aspect of meaningfulness, though it is never explicitly called that in Jung et al.'s work - this was my interpretation of it, and how I understood it as it formed part of my lens on meaningfulness. I return to this in the annotated portfolio chapter in regards to establishing *links*. A further exploration of these links is in Carpenter and Overholt (2018).

Similarly, Milling in a thesis on philosophy (Milling, 2015) presents his understanding of meaning in terms of aesthetics and everyday objects. I was introduced to his work as he was interviewing IdemoLab about how we design technology as part of his thesis and thus, his work has likely had influence on how I relate to everyday objects. His work (in philosophy, and therefore technically outside of HCI) is concerned with precisely the same arguments we encounter in HCI namely, embodied interaction being a source of meaning as we relate to the context we are in, and the objects within that context.

Milling explains, "By considering how perceptual experience comprises the full intermingled spectrum of: sensory modalities; form and dynamics; bodily reactions; and "higher-level" emotional qualities; we can understand what it means for aesthetic experience to be immanently meaningful and, thus, how aesthetics is crucial for how we make sense of things through sensory perception." (Milling, 2015)

Without delving too deeply into philosophy as it is simply not my area of expertise, I can appreciate this phenomenological perspective as it occurs in HCI (one example being Kozel, 2007) and relate it to my own work in that this aspect of aesthetics as being meaningful is essentially one of the key qualities I am exploring through the Manifestations of Meaningfulness.

Aesthetics is a common topic in HCI: Davey (2014) explains, "meaningfulness requires contextual and speculative relationality" which relates to Jung et al.'s presentation of linkages and Hallnäs and Redström, early in the days of defining HCI (2002) explain:

> "When computer systems change from being tools for specific use to everyday things present in our lives, we have to change focus from design for efficient use to design for meaningful presence"

(Hallnäs and Redström, 2002)

which again speaks to everyday objects, and presence, both of which are important qualities in my exploration of designing for meaningfulness.

The temporal aspect of meaningfulness also begins to unfold here. Jung et al. explain "the meaning of an object is built up over time as it is related to memories of loved ones, or active and/or frequent interactions" (Jung et al., 2011) and again, they are talking about the meaning of a thing to a person, not necessarily, a meaningful experience.

A meaningful experience might be attained through the use of an object which holds meaning for a person but determining whether or not this experience is meaningful and designing for that is the challenge. This aspect of temporality emerges again in Mekler and Hornbæk's work (2018) where they compare hedonic qualities to eudaimonic qualities, noting that eudaimonic qualities were longer term than hedonic qualities. Hedonic qualities are in-the-now, but not devoid of meaning as per Mekler and Hornbæk, and eudaimonic were long-lasting qualities carried through life. Löwgren also explores the temporal aspect of rhythm, describing the "ebb and flow of everyday life", and that interaction has an inherent factor of rhythm. (Löwgren, 2009). Vallgårda et al. (2015) discuss the temporal aspect of experience, explaining that there are "four temporalities at play in any interaction design: the temporality of the human, the temporality of society, the temporality of the computer, and the temporality of the input/output compositions (the physical form)." continuing "The temporality of the human is characterized by our ability to perceive the passing of time not just consciously but also in our embodied actions." (Vallgårda et al. 2015). This is important to meaningfulness, as I point to in the my third takeaway, *Enabling people-to-time links to allow for reflection and the making of meaning*. (Exemplified and elaborated on in Chapter 9: Takeaways and in Carpenter and Overholt, 2018).

In discussing Slow Design (discussed also in Chapter 8: Moments of Significance) Grosse-Hering et al. (2013) describe how "Slow Design could provide designers with an insight into how to design products that promote a more meaningful interaction to promote this reflection and appreciation which may ultimately support product attachment" and go on to explain that "meaning resides in this relationship between action and outcome". This is very close to my ambition for looking at designing for meaningfulness in smart products. My hope is that by opening a design space for researchers in designing for meaningfulness, that companies eventually can benefit as they create products which people do want to be attached to, in that the products help them to lead a meaningful life, and therefore, they care about those products. This is where the action and outcome exist, by using these devices, designed for meaningful experiences, the outcome might be a meaningful life and at least encompasses aspects of the mechanics: personal development, moments of significance, value over function, meaning in everyday life, and critical reflection.

In the implicit expressions of designing for meaningfulness, through the works and theories presented, from physical computing to eudaimonia, and the mentions of meaningfulness which I have encountered and presented here, I hope to make *explicit* an initial exploration of what it might mean to design for meaningfulness. This is done with full respect to the fact that I have most likely not found every reference to meaningfulness or meaning-making and with the understanding that this dissertation *points* to a space where designing for meaningfulness can be defined.

Part of this initial exploration might include aspects of ambiguity or prescribed values, as per Ghellal (2017) or it might be tightly coupled with embodied interaction leading to understanding how we are in the world, from a phenomenological perspective of perceived experience as we relate to everyday objects around us and engage with those objects. As we engage using our bodies, we therefore form meaningful experiences and further, we create links between these objects, which create a sense of meaningfulness as we ascribe value to certain experiences. Finally there is an aspect of time, the long-lasting nature of eudaimonic qualities, designing for human flourishing, for purpose in life, and the shorter term hedonic, pleasure based qualities.

This sums up to designing smart products which people *want to use* and which offer a meaningful experience. Some of this might come from for example, designing for reflection and slow design, some perhaps from designing for positive technology and well-being, and some from designing for tangible, interactive experiences as we experience the world around us.

What I propose in this dissertation is an explicit arrow, pointing towards designing for meaningfulness. I expect that what I have accomplished is starting to form a map of this area, identifying some of the key theories that reside here, and uncovering some of the value based characteristics (Mechanics of Meaningfulness) and the Manifestations of Meaningfulness (the four physical characteristics) and present the three takeaways for designing for meaningfulness which future researchers can use as a baseline upon which to begin their research journey.

5.3 Summary of drifting

The topics explained in this theoretical drift chapter indicate multiple drifts:

1. A drift from early physical computing and interacting with a desktop computer to immersive full body, ubiquitous systems;
2. A drift from tangible interaction and examining how we interact with designed interactive artefacts to experience design where we look at the greater social, philosophical and psychological intentions and impact of these designs;
3. A drift from designing for mental and physical health towards goals of identity and sense of self such as fulfilment, virtue, satisfying lives and ultimately, purpose and principles.

It is within this third drift that my research finds its foothold, exploring how to design for people to lead meaningful lives and have meaningful experiences within the context of smart products.

6

ENGAGEMENTS


designing for
MEANINGFULNESS
Case Study:
Fibo: A pregnancy wearable for men
people are usually m
fibo

6. ENGAGEMENTS

These engagements can be considered a gallery (Koskinen, Binder and Redström 2011) wherein the design artefacts are the final presentations of the process of considering both the intended impact of designing for meaningfulness and the physical characteristics of technologies which lean towards a meaningful experience. These engagements are part of the contribution of this dissertation, as a collection of artefacts where the qualities of each are exemplified in detail, and thus lead towards the Mechanics of Meaningfulness and the Manifestations of Meaningfulness.

Each design artefact is presented in terms of concept, user scenario, physical build description, and the Mechanics and Manifestations of Meaningfulness. As each engagement occurs in a different domain, the related works of these are not presented here, and instead appear in the publications and submitted works as they relate to each specific engagement.

6.1 FIBO

THE PREGNANCY WEARABLE FOR PARTNERS

Fibo is a haptics based pregnancy wearable which moves in real time as the baby moves, allowing the partner to feel the movements of the baby, including kicks, hiccups and pushes. The movement is based upon a patch which the mother wears, detecting the baby's movement. At the time of writing, we are seeking to partner with on-market patches which generate this data but have not yet confirmed partnership.

With Fibo, the concept was to find a way to connect partners, in a visceral way (Vallgårda, 2014) to their unborn babies, and further to the mothers and what they are experiencing. At the beginning of the project, the students began their research in the streets of Nørrebro, a trendy district in Copenhagen, home to many young families. They noticed many partners caring for babies, and many pregnant couples walking the streets together. The idea for Fibo was born from this observation and from asking the partners what they would like during the pregnancy, to which the majority replied: to be more involved.

Note: Although Fibo has been presented before, we present it here again as part of the collection of engagements.

Introduction

Fibo emerged from a class I was teaching in “Wearable Technologies” which is part of a 3.5 year bachelor’s program in jewellery design, technology and business at KEA[1]. The concept for a pregnancy wearable for men came from interviews with parents wherein the partner indicated that they wanted to be a greater part of the pregnancy itself, before the baby was born. The initial prototype was developed within the class with my guidance, and the jewellery designer’s expertise. The student team who created Fibo, later formed the company: First Bond Wearables and are now developing this early prototype into a product with the help of IdemoLab.

The aspect of jewellery design was important here and my design criteria to the students included a non-screen approach and using unusual sensors. This was based on my research at the time, which was at the beginning of the PhD research period. Of particular interest was the role of ‘enchanted objects’ and the portfolio of David Rose (2014) in which he presents a series of arguments and objects, which focuses on the role of the everyday object as a companion. One such example of this is The GlowCap, which uses an everyday object, the pillcap, to nudge users into remembering to take their pills. This uses a non-screen approach to visually (via glowing) reminding users to take their pills and has become a successful on-market product which has been “proven in a randomized clinical control trial to increase adherence to over 90%” (https://enchantedobjects.com/#/glowcap/).

User scenario

A woman, quite pregnant in her third trimester, can feel the kicks, pushes, hiccups and movements of her baby. She is sometimes delighted, sometimes frustrated, and sometimes exhausted by this. She wakes up and puts the baby monitoring patch on her belly. Her partner awakens and puts on Fibo, a wrist-worn wearable allowing them to feel the movements of the baby. They begin their day and her partner heads off to work. Throughout the day, they can feel small and big kicks, hiccups and pushes as they baby is active throughout the day. When they arrive home later that night, they rush in to speak to the mother, stating, “wow, what did you eat for lunch? The baby had the hiccups for half an hour, that must have been rough on you!”

Physical build

It was important to incorporate the feeling of the baby moving, as one parent commented, “babies don’t vibrate” so a major design quality became how to translate the movement of the baby, not just kicks, but hiccups and pushes, through Fibo, to the partner. After researching sex and massage devices, the

1 *Københavns Erhvervsakademi*

jewellery design students developed a design incorporating four balls of varying sizes which moved around on an axle, driven by a small servo motor. Early user testers, specifically, mothers, agreed this was a good representation of the movement of the baby. However, in this early form, the electronics and components could not be incorporated into a realizable wrist-worn wearable. Given this, we had to re-think what the physical form and interaction would be to achieve this feeling.

IdemoLab experimented with a variety of methods to translate this movement including linear actuators which resulted in a tapping sensation, and not the intended kicking or pushing sensation (though it would have worked for hiccups); vibration motors using vibrotactile illusions: vibration resulting in the perceived feeling of something such as a stroke, or a push (Schneider and MacLean, 2014) which resulted in a noisy prototype with the sound of the motors; and finally nitinol memory wire which shapes a textile based wrist wearable into different squeezes, imitating the movement of the baby through a variety of shape changes.

At the time of writing, Fibo is being developed within IdemoLab in partnership with an industrial design company, a service design company and a software solutions company. However, the commercial partner for the patch worn by the mother is not yet confirmed although a selection of companies is in dialogue, including BloomLife (https://bloomlife.com/) who have an on-market patch for detecting contractions (and who plan to expand to fetal monitoring); TinyKicks (http://tinykicks.com/) who do not yet have an on-market patch but suggest one on their website, and HapyMedical, a company which was a spin out of DELTA.

Manifestations of Meaningfulness

Fibo was designed to explore the tactile feedback possibilities of a reactive device, instead of using lights, sound or a notification as indicators, the student team put effort into the design of how to communicate this intimate moment. This tangible experience recalls both bodily engagement (Larsen 2015) where the body acts or is acted upon and also phenomenological resonance as explored by Kozel (2007) who explains: “The phenomenological experience of another person unfolds across physical description with latent conceptual elements extrapolated and can be relevant to me based on my having experienced the same thing, or simply because I have the ability to construct meaning empathically, perhaps through imagination or previous experience. Quite simply, I can resonate with another’s experience.”

This felt experience recalls the work by Núñez and Loke (2017) who explore how to elicit emotions and memories by placing vibration motors or heat elements on the body. They explain, “The perceptible feedback generated by wearable props opens up a dialogue space between the soma and intellect, acting as a facilitator to connect people with unknown aesthetic aspects of their personal stories."

With Fibo, it was vital to have a tactile experience which represented the movements of the baby. While an app may have been able to notify the partner of movement, translating this data into tangible, tactile information has the potential to resonate far more and create understanding and a common experience. Larsen, in his dissertation explains sensuousness as a quality of his designs, (Larsen, 2015, p. 182) and explains how nuanced understanding of interactions emerge from bodily engagements. He describes how games such as Wii or Kinect allow for interaction but that this is not comparable to the "bodily feel of, for instance, hugging the soundscape of *HugBag*". (Hugbag is one of his engagements wherein a person hugs a bag which emits a responsive soundscape). This bodily feel is the essential aspect of Fibo, wherein the partner can connect, *bodily*, to the movement of the child and to some extent, to the experiences of the mother. In stark contrast to this, we experienced on a (surprising) number of occasions when Fibo was on display at a trade show or being demonstrated in a meeting, a male who would comment on Fibo, saying, "oh, but you wouldn't want to wear that in meetings, or all day, it

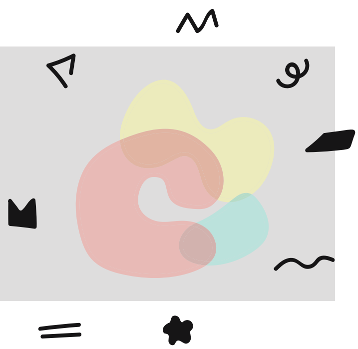
Figure 11: An early image from First Bond Wearables. Used with permission.

would become annoying to feel the baby, and distracting in meetings", much to the fury of the mothers involved in the study, who are at work until late in the pregnancy before going on maternity leave. This reinforced our belief that Fibo was necessary as a wearable, tactile experience: partners are generally not physically involved in the pregnancy the way the mothers are. And while we do not suggest that a wearable can mimic the feeling, discomfort, joys, and overall physical and psychological experience of being pregnant, we do suggest that having a tangible connection to the movement of the baby has the potential to change the partner's perspective, both in terms of their connection with the baby, with the mother and with themselves as they develops their identity as a parent.

Mechanics of Meaningfulness

Fibo is representative of the aspect of *personal development* within my framing of meaningfulness. This is in regards to how the partner, feeling the movement of the baby, has the potential to develop as a parent and a more active part of the pregnancy. Further, it represents the connection between both partner and baby, partner and mother, partner and society and partner and self in that in all these areas, being aware and involved in the baby's movement may contribute to better communication, greater perspective, and even a changed role. Finally, it results in critical thinking and attitude change as the partners reflect on their role and *become* parents.

Fibo: This diagram represents the connections which are part of the Fibo engagement. Here we can see people-to-people, a person-to-sense of self, and people-to-time. It has aspects of the Mechanics of Meaningfulness (Personal Development, Moments of Significance, Value over Function, Meaning in Everyday Life, Critical Thinking) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Craft).



Credits
http://firstbondwearables.com/
Sandra Pétursdóttir, Director, First Bond Wearables
Eszter Smit, team member of First Bond Wearables
Henriette Ryder Andersen, team member of First Bond Wearables
Vanessa Julia Carpenter, technical and business advisor
IdemoLab, technical development

Publications
Carpenter, V. J., & Overholt, D. (2017, June). Designing For Meaningfulness: A Case Study Of A Pregnancy Wearable For Men. In Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems (pp. 95-100). ACM.

Carpenter, V and Overholt, D. (2018) "Designing for interpersonal connections in future technologies: An annotated portfolio of jewellery devices". Proceedings of the 2018 NordDesign conference. Design Society.


FIRST BON
WEARABLE

6.2 ELECTRONIC KINTSUGI

AN INVESTIGATION OF EVERYDAY CRAFTED OBJECTS IN TANGIBLE INTERACTION DESIGN

Kintsugi is the traditional Japanese craft of repairing broken ceramics with precious metals which Tsaknaki and Fernaeus introduce in their 2016 work on Wabi-Sabi in HCI. Wabi Sabi loosely translated is the art of imperfection. Kintsugi is beautiful namely because of the imperfection, being able to see where the cracks have been and where someone has skillfully and lovingly repaired the ceramics. Electronic Kintsugi is a way to interact with this imperfection, to embrace it and to experience aspects of meaningfulness from the interaction with the precious metal traces in the ceramic.

Electronic Kintsugi takes the form of a Kintsugi bowl, a piece of Japanese traditional craft, created with a Japanese crafts person, wherein by stroking the precious metal traces, sound and light reactions emerge and evolve over time.

Stroking the Kintsugi was not a means to an end, it would not start your coffee maker or send an email; or any of the other IoT (Internet of Things) typical solutions. Instead, it was about playfulness, experimentation, and discovery.

Introduction

An extensive description of this project and the two workshops is available in the publication *"Electronic Kintsugi: An investigation of everyday crafted objects in tangible interaction design"* (Carpenter, Møbius, Willis and Overholt, 2018) the following provides a brief overview of the activities and primary findings.

Drawing from Tsaknaki et al.'s (Tsaknaki, Fernaeus and Schaub, 2014, Tsaknaki et al., 2017, Tsaknaki, Fernaeus and Jonsson, 2015) method of in-context work with craft persons, I co-organized a workshop in Japan at FabCafe Tokyo with the curator of the lab and a Kintsugi artist, Kurosawa. Together, we designed a workshop wherein participants were invited via FabCafe Tokyo's network, to join for an introduction to Kintsugi from Kurosawa, an introduction to Electronic Kintsugi from myself and my partner, and a hands-on experience trying out Electronic Kintsugi and discussing the results.

The workshop participants were both Japanese and not-Japanese, all living in Japan and having some association to the FabCafe. There were many ideas, reactions and insights gained, some of which led to alterations in the Electronic Kintsugi code for our second workshop in Copenhagen. We distributed the now-updated Electronic Kintsugi to design researchers in Copenhagen, following the method proposed and used by Wakkery et al. (2017) to experience in their homes for a period of 5 weeks, after which we gathered for a workshop to discuss their insights and ideas. These workshops are described in the publication.

From these two workshops it was clear that the Electronic Kintsugi, an intentionally 'unfinished' work, was of interest to participants and generated engaged discussion, debate and ideation. It is an open-platform wherein the user might choose to play with it, eat with it, communicate through it, or simply exist with it.

User scenario

Three brief scenarios are described here, arising from actual use cases with our design researchers:

A man living in Denmark, but not yet fluent in Danish, has an awkward moment: he's left in the living room with his Danish girlfriend's father, who speaks little English. Left alone for some time as the girlfriend gets ready to go out, they lack the common language to exchange pleasantries. Suddenly, he remembers the Electronic Kintsugi and uses it as an icebreaker, a common language for them to play with, explore, and as a way to enjoy the time together.

A woman has friends over for drinks, and after much conversing and visiting, everyone is tired and people begin to head home. On their way out, one of them brushes by the Electronic Kintsugi and it lets out a low tone. Startled, they turn around and begin to touch it again, and it begins to sing. Suddenly, everyone is excited by this new thing, and she explains what it is and shows them how she uses it, and they spend another 45 minutes in her entranceway, entranced by the Electronic Kintsugi.

One of the design researchers took a gamble, and decided to eat their breakfast cereal from the bowl. Worried they might damage the electronics, they were careful at first, and then realized that all was fine, and began to truly enjoy and analyze the act of eating. They could tell at which point they were eating too quickly, or mainly getting milk instead of cereal, or when the spoon touched the bowl rather than the food. An ordinary breakfast turned into something extraordinary as they experienced cereal like never before.

Physical build

Electronic Kintsugi was co-developed with Nikolaj “Dzl” Møbius who utilized his (and Mads Høbye’s) Touche (Touche, 2018) for Arduino library and his own Arduino Synth library (Møbius, 2018) to create both reactive capacitive touch and sound. A box was built, containing a speaker, an Arduino board and a small (3cm) strip of NeoPixel LEDs. A wire attached at one end, to the box and at the other end, to the Kintsugi. In this way the box was the electronics, and the bowl was nearly on its own, being attached only by a wire. We originally imagined interaction with both light and sound, independently, one could swap between modes. However, after the first workshop, we learned that the light was not as easy to understand due to the lack of tight coupling (Larsen, 2017) between touch and light reaction. In the second workshop, participants told us that they had decided not to use the light mode at all and concentrated on the sound.

Upon arriving at the FabCafe Tokyo, we worked with Kurosawa, a Kintsugi artist to determine whether or not the traces in her Kintsugi would be conductive enough for our purposes. They were not, so we worked with her to cut copper tape to match the traces and asked her to overlay this on the traces in the manner she saw fit to match her craftsmanship as best as possible. We decided to remain with this aesthetic as our focus was on the interactivity and how people experimented with it, rather than exploring how to actually craft the object itself. This relates back to the method of research through design, as we were not aiming for a perfect product which would be deployed on-market, but rather, it should have the aesthetic of a prototype, a rough box with an Arduino board strapped on top, with a wire connected to a bowl with copper wire on it. In this way, participants could imagine possible futures for this object without us clouding their creativity with finality in design.

Manifestations of Meaningfulness

The aspect of craft, and preciousness (Tsaknaki, 2017) was essential for the underlying exploration of designing for meaningfulness. As one participant commented, "if this was an IKEA bowl, I might not have bothered so much" and one of the Japanese participants was excited to be allowed to play with art, traditional Japanese craft, in this way. Although we did not dive into craft the way Tsaknaki did in her dissertation, her exploration of preciousness through craft in HCI was relevant, She describes three qualities of preciousness:

1. *Resourceful composition: Spending time and effort exploring the available material space in depth*

2. *Material sensuality: Preciousness emerging through physically interacting with materials*

3. *Mattering artefacts: aiming for designing computation things that would "matter", firstly for the designer, and most importantly for the user, over time.*

(Tsaknaki, 2017, p. 131).

These qualities of preciousness are important aspects of the physical materiality which Electronic Kintsugi explores. We did not spend time

Figure 12: Kurosawa, the Kintsugi artist demonstrating her technique.

and effort exploring Kintsugi in depth, but Kurosawa, the Kintsugi artist, has spent years of her life exploring this, while we have spent years of our lives exploring how to interact with technology in a tangible, invisible way, as per my past projects presented in Chapter 5. Together, our backgrounds lend to *resourceful composition*. Physically interacting with Electronic Kintsugi resulted in a range of experiences, emotions and qualities, the qualities are described below. This idea of sensuality in interaction originates (or at least, was first popular) with Löwgren's use qualities (2006) and is still relevant and important, 11 years later. Without the sensuality of touching, caressing, exploring the Kintsugi traces, Electronic Kintsugi would simply be a bowl which squeaks when you put your hand on it. Finally, *mattering artefacts* is of particular interest, for it is this reference to temporal qualities which is interesting for meaningfulness, it is not just the experience in the moment, but the lasting quality which lends towards meaningfulness. In the three user examples, we have a new relationship built between father and daughter's boyfriend, we have a new way of engaging with friends, even when tired, and we have an appreciation for the simple act of eating cereal.

Mechanics of Meaningfulness

From the two workshops, and reflection before, between, and after, three qualities emerged from this project about designing for meaningfulness. While these echo, to some degree, Tsaknaki's qualities of preciousness, interestingly, her dissertation was still being written as this study was being conducted. This speaks to the importance of these topics in HCI at this time, as various researchers begin to propose similar hypothesis, or simply re-imagine older ones.

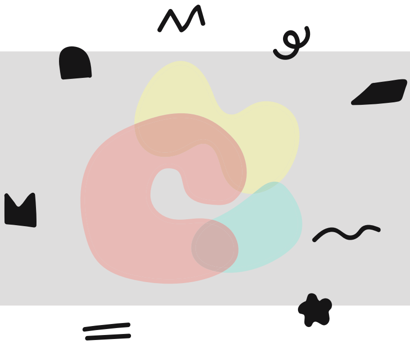
As described in the publication "Electronic Kintsugi" by Carpenter et al. (2018) there are three outcomes which relate back to this dissertation and the mechanics and manifestations of meaningfulness (for full description, please see the publication). These are:

1. enhancing human connection through embedded or "magic" technology,
2. using everyday objects to prompt personal reflection and development,
3. exploring transferable design principles of smart products with a device of undefined purpose and which converges traditional craft and technology.

In 3, above, the transferable principle is the aspect of an undefined purpose. Many consumer facing smart products today focus on offering one specific purpose, a smart water bottle which tells you how much water you have had and when it is time to drink; a smart toothbrush which gives you feedback on your brushing; a fitness tracker which tells you how many steps you've taken and need still to take. Offering a product which has no defined purpose is perhaps reminiscent of a decorative plate or bowl. Maybe it is used as decoration, or to hold keys, or candy; by adding interactivity to this object it might offer an opportunity to engage with it, with oneself and with others.

Electronic Kintsugi is an exploration of everyday objects, enhanced by craft, intertwined with technology. The bowl is an 'everyday object' and something you would likely have around the home. It invites for interaction with the presence of the copper tape traces. In this way, the bowl can act as a trigger for interaction, much like Mols et al.'s 'trigger for reflection' (2017, March). The bowl becomes appropriated by the user (Turner and Turner, 2013) and not only do they make it their own, but they find their own meaning within the use of it. And, as Turner and Turner (2013) explain, "We are emotionally and aesthetically attached to artefacts which are proximal and close at hand". The ability to just reach into the Electronic Kintsugi bowl and idly begin to play with it is an affordance of sorts, changing an everyday object into an enchanted one.

Electronic Kintsugi:
This diagram represents the connections which are part of the Electronic Kintsugi engagement. Here we can see people-to-people, a person-to-sense of self, and people-to-time. It has aspects of the Mechanics of Meaningfulness (Personal Development, Moments of Significance, Value over Function, and Meaning in Everyday Life) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Craft, Everyday).



Credits
Concept: Vanessa Julia Carpenter
Arduino Synth: Nikolaj "Dzl" Møbius
Touché for Arduino: Nikolaj "Dzl" Møbius & Mads Høbye
Programming & Hardware design: Nikolaj "Dzl" Møbius

Publication
Carpenter, Vanessa Julia, Møbius, Nikolaj "Dzl", Willis, Amanda, Overholt, Dan. Electronic Kintsugi: An investigation of everyday crafted objects in tangible interaction design. Proceedings of the 2018 IEEE Future Technologies Conference. Springer, 2018.

6.3 TRÆKVEJRET

SERENDIPITOUS DISCOVERY OF A NON-CONNECTED ARTEFACT LEADING TO SUBTLE, SPONTANEOUS BODILY REFLECTION

Trækvejret is a small, wooden object which moves in an inward and outward motion at the rate of human breathing. On the object is written a simple instruction “breathe” (“Træk vejret” in Danish). It is placed in the context of a coffee break room, and as people enter the room, they serendipitously discover the artefact, and upon watching it for a moment or two, begin to take a few deep breaths as they wait for their coffee.

This began as an observation: As people used the coffee machines at FORCE Technology, they press a series of buttons, put their cup down, and waited 40 seconds for a coffee to be dispensed. During this time, they would check notifications on their phones but could not address these in the limited time frame. It appeared to me as a casual observer like time spent there was less of a coffee-break and more of a potentially anxiety-inducing waste of time. I considered how to reduce anxiety and stress, and was reminded of breathing techniques. I considered what might happen if we offered people an opportunity to just stop and breathe. These 40 seconds could be used for bodily awareness and getting more oxygen to the brain.

Introduction

An early sketch was developed using a piece of kerf-bent wood which could mimic the movement of breathing in and out. This was deployed in a series of evaluations in the coffee break rooms, resulting in many people stopping and considering the device and taking the time to take a few deep breaths. The results of this are in the submitted paper “Trækvejret: A kinetic device encouraging bodily reflection” (Carpenter, Sokoler, Møbius, and Overholt, 2018).

Although the object itself is quite simple, the potential impact is significant. People learning to take a deep breath, training this as a practice, just as they have trained themselves to get up and get a coffee every hour or so. One colleague asked why they couldn’t have one on their desk, and my answer was that this would defeat the entire purpose. It’s like brushing your teeth, it is a learned, bodily habit. My night routine (and I would argue, most people’s) involves brushing my teeth before bed. I feel uncomfortable if I haven’t done this. I would hope that people feel the same with breathing, eventually. Upon encountering the device repeatedly, I would hope that people had taught themselves to take a breath at various points throughout their day, just like when they feel the need to get up, stretch their legs and get a coffee.

Furthermore, this object is neither connected nor is it interactive. It is the opposite of quantified self, it does not measure anyone, nor does it offer feedback. It does not measure and record how often people breathe with it. Instead, it is non-connected and in the paper, we point to a design space wherein non-connected, physical devices might be an interesting area to explore. From the submitted paper:

> *“We initially propose the definition of this space as being one wherein research through design is a method to propose sketches featuring simple, non-connected devices for the betterment of the self, preferably in a combination of physical and psychological aspects. In this space, the interaction is not data-driven or data-collecting but rather is passive, and potentially as beneficial through encouraging people to explore their own abilities. We expect that this framing expands, contracts, and moves in directions we can’t imagine now but hope it pushes boundaries of what we might expect.”*
> (Carpenter, Sokoler, Møbius, and Overholt, 2018).

This aspect of non-connected is important as part of this dissertation. It demonstrates how a device might enable a meaningful life, one where a person takes breaks and is concurrently aware of their physical state, taking the time to reconnect to their body. Further, the question of *why* something should be connected is important. Trækvejret is shown to work as intended, even in its simplistic sketch state, and deployed over only two days. People did reflect on their breathing and their connection to their body, and no IoT-dashboard was needed. As Hartzog and Selinger (2016) explain, ‘A chip-centric mentality has taken over, one that is guided by an overly simplistic principle: ‘Internet connectivity makes good objects great”. This simple statement opens a floodgate of reasons or lack of reasons for connectivity, which will be discussed in Chapter 8: Offline.

User scenario

“A person at work feels it’s time for a cup of coffee and walks to the coffee break room. They put their cup in the coffee machine and as they wait for their beverage, they discover a small wooden object moving beside the machine. They are curious about it and regard it for a moment, before realizing it is imitating breathing. They sync their breathing to the device, taking a few slow, deep breaths”. (Carpenter, Sokoler, Møbius, and Overholt, 2018).

I add to this a future scenario:
“This person who originally encountered Trækvejret has come to look forward to their daily routine of getting a coffee and taking a few deep breaths while they wait for the machine to dispense their drink. They use this time to match their breathing to Trækvejret and throughout the day can recall the rate of breathing and take a few deep breaths each time they remember, usually once or twice per hour, gaining a sense of calm and bodily connection with each session.”

Physical build

Trækvejret consists of a servo motor, mounted on a piece of MDF board alongside an Arduino board. The Arduino is running the “Sweep” example programmed to the rate of human breathing[1] which drives the servo at a constant rate, moving up, pausing and moving down. The servo is attached to a piece of kerf bent MDF (wood laser cut so it can be bent like a textile) and it is this piece of wood which moves up and down, giving the impression of a stomach breathing in and outwards. It is always powered via an electrical wall plug, so it is always on, and consistent in its movement.

Manifestations of Meaningfulness

This is a non-screen device, however it is visual. People interpret its movement differently, some see the outwards motion of the wood as a stomach expanding with breath and some see it as a rounding and straightening of the back with each breath.

Throughout this dissertation, the debate of non-screen versus non-visual has emerged again and again, the aspect of a screen is something which Rose refers to as the “black mirror” (Rose, 2014) and visual can mean, in this case, something which visually represents bodily engagement. In their work, Bewley and Boer utilizes visual and tangible experiences which provoke

1 *https://www.normalbreathing.com/index-rate.php*

and intrigue. They present Blo-nut, "a prototype designed to explore human interpretation of an animated and abstract artefact intended to exhibit provoking and life-like behaviours." (Bewley & Boer, 2018). Although aimed at soft robotics, Bewley and Boer present three relevant qualities which Trækvejret al.so exhibits: *Juxtaposition:* "A surprising and playful juxtaposition of form and expected movement"; *Elasticity:* "A combination of form, material and construction that allows for the maximum possible expansion/ transformation of neutral shape for maximum temporal dexterity"; and *Robustness*: "a robust and handleable form that lends itself to physical interaction is crucial". Trækvejret, when first encountered, is wooden, and the soft, shapely movement of it moving inwards and outwards is unexpected given its wooden form. It combines small scale format (standing only 15cm high) with flexibility, moving outwards 5 cm with each movement (elasticity). And although Bewley and Boer are discussing the physical robustness of the Blo-nut being handled, the aspect of robustness is an important quality for Trækvejret, that it has an aesthetic of wood, which is durable, yet flexible and relatable as a material, and it mimics the physical interaction of moving. It has, in this way a physical affordance (Harston, 2003) towards physical movement, towards breathing, whether by the extension of the stomach outwards, the lungs filling with air and expanding or the backing in rhythm with the breath.

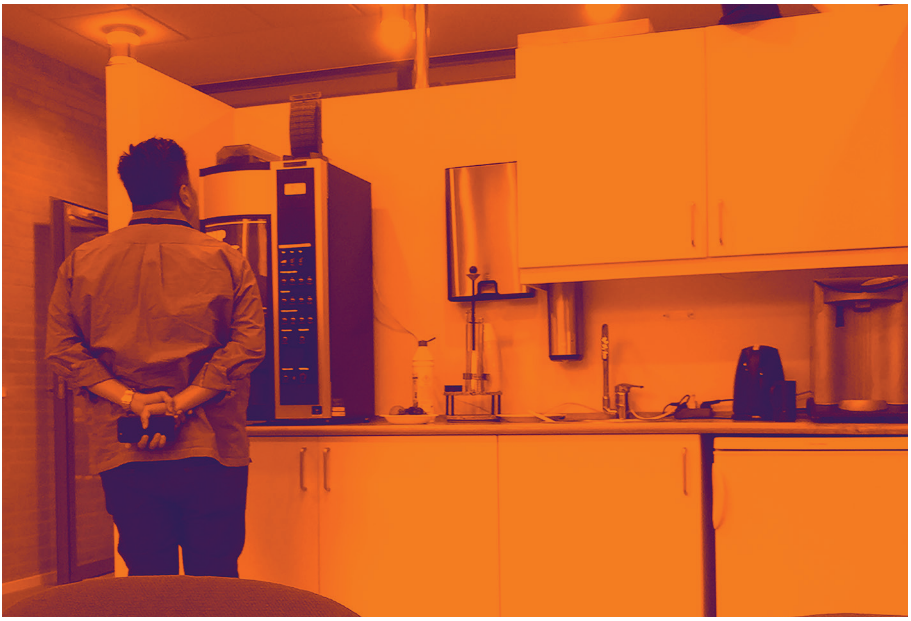
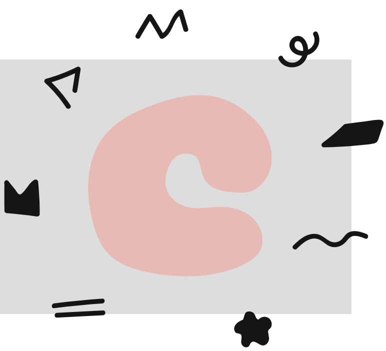


Figure 13: A person at FORCE Technology getting a cup of coffee and engaging with Trækvejret.

Mechanics of Meaningfulness

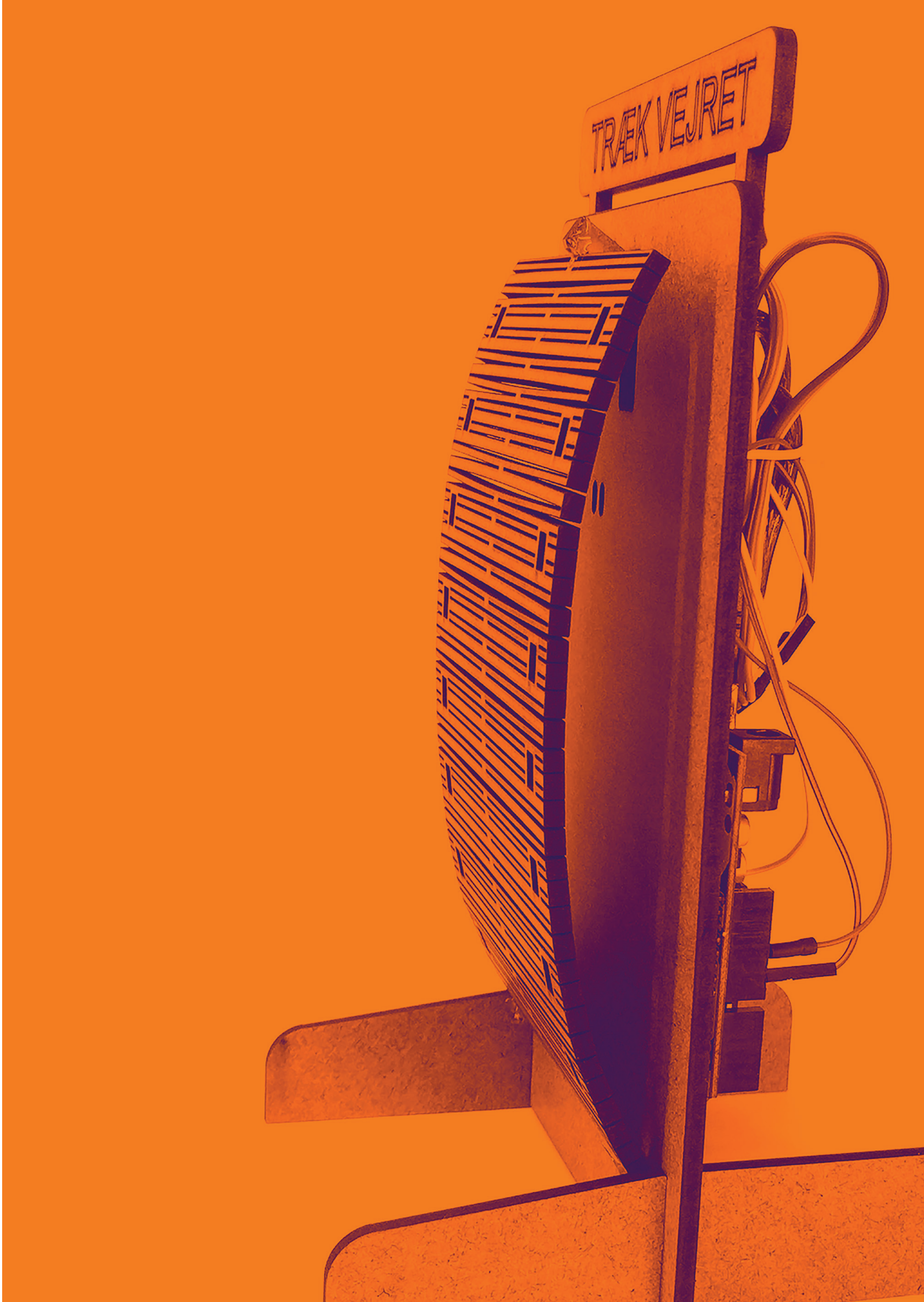
In this engagement, the emergent quality is more of an emergent design space, and that is what we propose in our paper. This design space, as described above, is one where multiple juxtapositions exist, the aspect of non-screen but visual, of non-interactive but physically affording, of non-quantified but better self, and of serendipitous discovery of a sketch leading to engagement with the sketch, essentially an unplanned experience. Participants did not enter the coffee room expecting to partake in a breathing activity, and perhaps, in future scenarios they might do just that, however in this design space, exploring these discoverable sketches, might be of interest to facilitate thoughtfulness, behaviour change and eventually meaningfulness in the sense of personal development and critical reflection. One might ask themselves how they have used their breaks in the past and how they expect to use them in the future, and simultaneously, how they use their body, is it more beneficial to tank up on caffeine (surely, sometimes, yes) but perhaps it could be equally beneficial to utilize oxygen as a means to enliven the body, mind and spirit.

Trækvejret: This diagram represents the connections which are part of the Trækvejret engagement. Here we can see a person-to-sense of self. It has aspects of the Mechanics of Meaningfulness (Personal Development, Moments of Significance, Value over Function, Meaning in Everyday Life, Critical Thinking) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Craft).



Credits
Concept: Vanessa Julia Carpenter, Daniel Overholt, Nikolaj "Dzl" Møbius, Christian Liljedahl
Device build: Vanessa Julia Carpenter
Software: Arduino, Servo-Sweep example.
User research: Guillaume Pierre Slizewicz and Morten Tranum Feldborg

Submitted paper:
Carpenter, V., Sokoler, T., Møbius, N., and Overholt, D. (2018). Trækvejret: A kinetic device encouraging bodily reflection. Submitted to Tangible, Embedded, Embodied Interaction (TEI), 2019.


TRÆK VEJRET

6.4 MUSCLE MINDER

USING TWISTED ACTUATORS TO FACILITATE MIND-MUSCLE CONNECTION DURING EXERCISES

Muscle Minder is a system to facilitate a better mind-muscle connection using a haptic cue, specifically a squeeze, to cue focus on a muscle before commencing with an exercise movement. This project originated as part of an external stay at the Sensory Perception and Interaction Lab (SPIN Lab) at the University of British Columbia, Canada.

In a team including Soheil Kianzad and Laura Cang, we had four weeks to explore how we might accomplish the task of facilitating mind-muscle awareness and focus using a non-screen, tactile approach. We had spent several months ahead of my visit discussing various use cases over Skype, and decided on the case of mind-muscle connection.

We developed an early sketch consisting of a string, pulled tight by a motor (twisted actuation) around the bicep of the wearer (given the context of doing bicep curls) and measured the muscle activity with using surface electromyography (EMG).

Introduction

We initially used the VibViz haptic library of vibrations (Seifi, Zhang and MacLean, 2015) to explore which vibrations might be useful for asking someone to focus. This library is an extremely useful tool developed by the SPIN lab wherein tactic vibrations are categorized into types of sounds, emotional qualities, and intensities. Working with this library gave me insight into how I might think about ways of using non-screen haptics to interact with people in new ways. In particular, I was intrigued by the “Usage Example Filters” which for the scenario of helping a person doing an exercise to focus on their muscle, perhaps something like “encouragement” or “get ready” would be appropropriate. (Figure 14).

An evaluation procedure was followed to try and avoid bias, wherein three tests were randomly assigned. One evaluated bicep curls with no cue, one with a short pulse cue (a quick tightening of the string) and one with a continuous cue (a prolonged tightening of the string). From our initial encounter with the sketch, we determined that having people focus on their muscles and providing them with a cue before each movement showed higher average EMG activations compared to continuous cueing or no cue. (a more in depth description available in the submitted paper: Muscle Minder: A haptic cue system for exercise (Carpenter, Cang, and Kianzad, 2019).

User scenario

Here I present two scenarios since part of the project included expert interviews, one of which was with a Clinical Assistant Professor at the Faculty of Medicine | Department of Physical Therapy at the University of British Columbia, so a physical therapy angle is also presented here. The first scenario applies to a professional athlete, recreational gym user, or a first time weightlifter.

Scenario 1: At the gym
A person enters the gym, it’s 'arms day' and they begin with a bicep curl. They are already wearing the Muscle Minder system as it is integrated into their Athos training suit[1]. They stand at the weight rack, holding two dumbbells ready to do a bicep curl. The gym is loud, as usual, music blaring, weights banging. They feel a tightening around their bicep and focus inwards, visualizing feeling and connecting to the muscle. They do the bicep curl, rest, and do the routine again and again, 10 times, tightening, focusing, connecting, curling, releasing, until the set is done.

Scenario 2: Physiotherapy exercises at home
A person who has suffered nerve damage in their arm due to a biking accident is trying to do their physiotherapy exercises. They are sitting in a chair, ready to do some bicep curls to help rebuild muscle in that area. When they are at the physiotherapist’s office, the doctor

1 *https://www.liveathos.com/*

squeezes their arm with their hand, guiding them through the exercise with words and physical touch. However, once they are home, it's hard to focus on the muscle and muster up enough strength to also do the exercise. They put on the shirt with Muscle Minder built in, and begin their exercises, receiving a squeeze before beginning each exercise, helping them to focus on that specific muscle and squeeze, hold and release it for the correct amount of repetitions.

Physical build

Muscle Minder consists of two parts. The first is an EMG sensor kit, the Myoware Muscle Sensor which sits on the muscle and has two electrodes on the board itself and then a separate one to be placed on the muscle. This measures the EMG, or how hard the muscle is working. A shirt was used to act as a carrier for the squeeze mechanism, and had a small motor attached to it, with a microcontroller controlling how often the motor activated. The motor was attached to a string and when activated, tightens the strings via a process called twisted actuation.

Manifestations of Meaningfulness

Muscle Minder is an early sketch, it is representative of a future object, and we imagined that it would be incorporated into some kind of smart workout clothing such as Athos which has built-in EMG sensors or Hexoskin[2] which measures heart rate and breathing rate. The interesting part of this sketch was the use of squeezing as an actuation modality.

Like Trækvejret, Muscle Minder isn't measuring anything, it is only (in its current state) squeezing on a timer, for each bicep curl you aim to do. The responsibility is left with the person to ensure that they use this cue to mentally focus on their muscle. Self-reliance is a recurring theme within this dissertation, with Trækvejret, it is up to the person to train themselves to take deep breaths. With Electronic Kintsugi, one could essentially ignore the artefact altogether, and it's up to what one makes of their own experience with it that is potentially meaningful. Fibo provides a tactile experience and again, it is up to the partner to discuss these movements with the mother, and reflect over his own role as a partner.

By focusing on the tangible experience of squeezing, not only do we introduce an element of self-reliance but we also demonstrate just one method of many for technology to act on people. No notifications, apps, blinking, beeping, or other typical ways of telling people to pay attention, this is a simple yet effective method of getting attention and communicating an intention - to focus on the muscle.

Mechanics of Meaningfulness

The quality of value over function is

2 *https://www.hexoskin.com/*

primary within this sketch, wherein the value is the person being able to focus on their muscle and train themselves to achieve a mind-muscle connection while doing exercises. Furthermore, this design artefact and the experience gained from evaluating it suggest an example of meaningfulness in the everyday, especially in relation to transformation. In the case of the person recovering from an injury, they are working on transforming not only their bodies but also their mind, overcoming the weakness in their muscles and through a very clear mind-over-matter situation, regaining muscle and strength in their arm.

These small accomplishments are important in a physiotherapy setting and when we spoke to the Clinical Assistant Professor, they suggested we also look to the Homunculus, a mapping of which body parts we are most aware. It was suggested that the back of the body has very poor representation and people are much less aware of muscle activity they can't see so this would be an excellent site for the introduction of such a device which acts on the body to facilitate mind-muscle connection.

Again, the focus here is on the value of a device which facilitates a better mind-muscle connection and the value of using bodily engagement via a device to do so, instead of simply having a function, such as a beeping timer, or a phone notification that would perhaps tell you to focus, but would essentially be far less bodily present, than a device acting *on* the body.

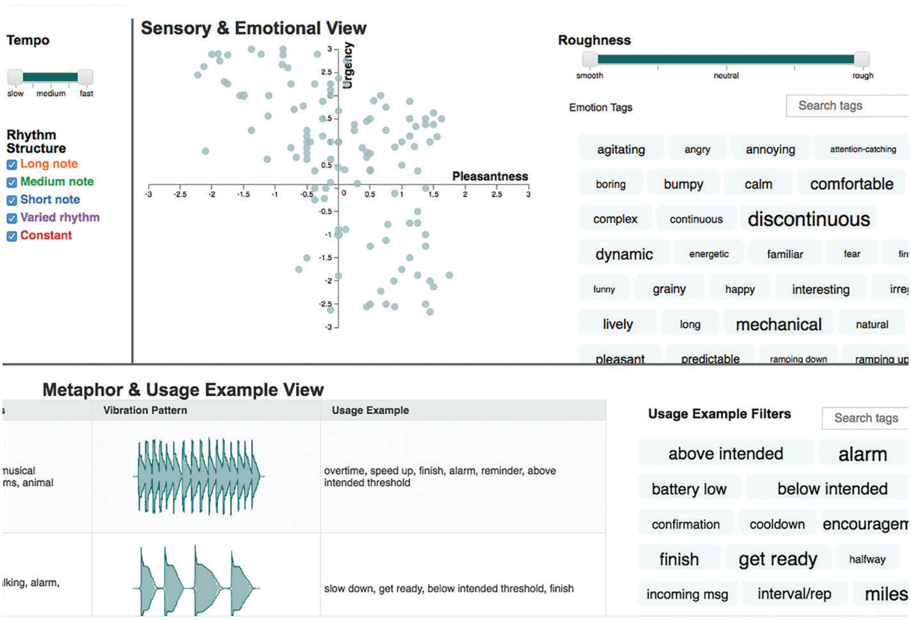
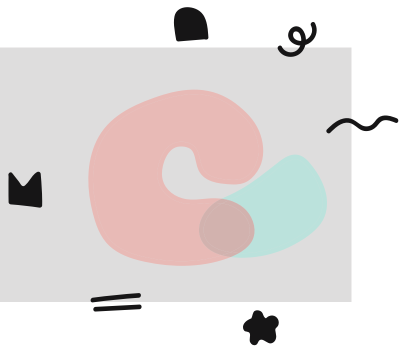


Figure 14: The VibViz haptic library of vibrations (Seifi, Zhang and MacLean, 2015).

Muscle Minder: This diagram represents the connections which are part of the Muscle Minder engagement. Here we can see a person-to-sense of self and people-to-time . It has aspects of the Mechanics of Meaningfulness (Personal Development, Value over Function, Meaning in Everyday Life) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Everyday).



Credits
SPIN Lab, UBC (https://www.cs.ubc.ca/labs/spin/)
Concept, Build and User Evaluations: Vanessa Julia Carpenter, Soheil Kianzad and Laura Cang
Supervision: Dr. Karon MacLean

Submitted paper:
Carpenter, V., Cang, L., Kianzad, S. (2018). Muscle Minder: A haptic cue system for exercise. Submitted to: CHI'19: ACM CHI Conference on Human Factors in Computing Systems, Glasgow. Late-Breaking Work

6.5 MUSICFABRIK/ SKETCHY TUNA

A PLAYABLE, PORTABLE SPEAKER

MusicFabrik originated as a student project at Aalborg University where I was coaching a group of students in their project. Now known as SketchyTuna, but originally called MusicFabrik, it was a collaboration with Libratone whom the students had contacted to find out if Libratone was interested in exploring other potential use cases of their Bluetooth portable speakers.

The student team was part of Aalborg University's Sound and Music computing program and so their interest was in designing new musical interfaces whereas my interest was in exploring non-screen, tangible interaction with everyday objects. We discussed how the Bluetooth speaker has become a nearly ubiquitous part of people's homes. We were intrigued by the concept of a simple, portable, wireless speaker. Our initial investigation was into how we might turn the removable, textile cover of the Libratone speaker into an interface for music creation. In a later prototype, SketchyTuna emerged as a full single-board computer with an additional audio interface communicating with a custom embedded MIDI controller. A real-time, loop-based musical software platform was developed as part of the high-fidelity prototype.

Introduction

A survey was done with 30 musicians who create electronic music, exploring the type of equipment they own and use and how they use it. This informed how the team might develop the controls and layout of the early MusicFabrik sketch. Upon creating a rough sketch, they began the first user evaluations with musicians in their homes to ensure they were both exploring how people might use the music functionality but also how the musicians related to the device as an everyday object they might use. These early evaluations were interesting and pointed towards ad-hoc use of the device to create music, either on the speaker itself, just picking it up to play, or by taking the cover off and using it as a more traditional interactive music sketch pad. This speaks to the everyday-ness of this object.

SketchyTuna was the next iteration of this early sketch, wherein various keyboard layouts were evaluated, a sketch pad controller was designed and PCBs were made for looper control, motorboard, and keyboard input. This is discussed extensively in the paper "SketchyTuna: Exploring A Design For Screenless Creativity." (Møller et al., 2018).

User scenario

A hobby musician comes home from work and settles into the couch. They aren't ambitious enough today to pull out all their synths and music gear, they just want to be creative and burn off a little work stress. They reach over and pick up MusicFabrik, turning it on and immediately beginning to explore different tones on the keyboard. They initialize the loop recorder and start to play along to to the loop they just recorded. In no time, they have a small composition made and they are ready to make dinner and settle into their evening.

Physical build

I describe here MusicFabrik since SketchyTuna was the second iteration and was predominantly the student's own project. MusicFabrik is a very early sketch, consisting of an interactive speaker cover using reactive textile, Eeontex pressure sensitive fabric, which is mapped to be a keyboard in a Wiki-Hayden layout. The cover is attached to a BeagleBone Black (low-power, single-board computer) connected to a Bela expansion board. An open-source TinySoundFont library was used for the tones. (For complete details and references, please see the publication).

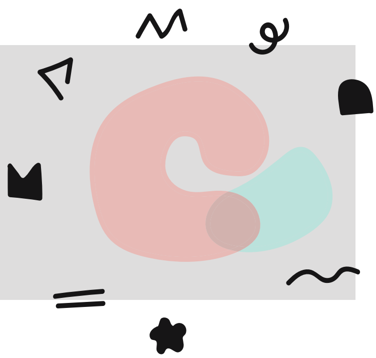
Manifestations of Meaningfulness

The point of this early sketch was to find out how we might augment the standard Bluetooth speaker with an interactive and creative element. In other words, we wanted to explore how an everyday object, the Bluetooth speaker, could act as an interactive element which is not 'always-on' but is an offline experience for personal expression and thus, personal development. There was no screen or traditional input methods such as an electronic music sketch pad with buttons. By integrating the input into the existing Libratone cover, we re-imagined a (now) everyday object, allowing for it to both exist in the home as a periphery object which we might not pay much attention to until we need to use it and also to act as an interactive device to help express creativity and develop as a musician.

Emergent qualities

This concept has meaningfulness in the everyday in mind as a primary quality. A person, expressing themselves creatively is building up their identity as a creative person, a musician. They might develop their skill set, be it creating music or connecting to their own music, or having a good ear for a loop which works well. The simplicity of the pick-up-and-play aspect means that they don't need to plan for this - it's timely in the sense of being available to engage with when a person has time and desire to do so. In some ways, it's reminiscent of Trækvejret and serendipitous discovery. They might know it is in their home, so it's not exactly discovery in the same sense, but it might enable spontaneous creativity and relaxation.

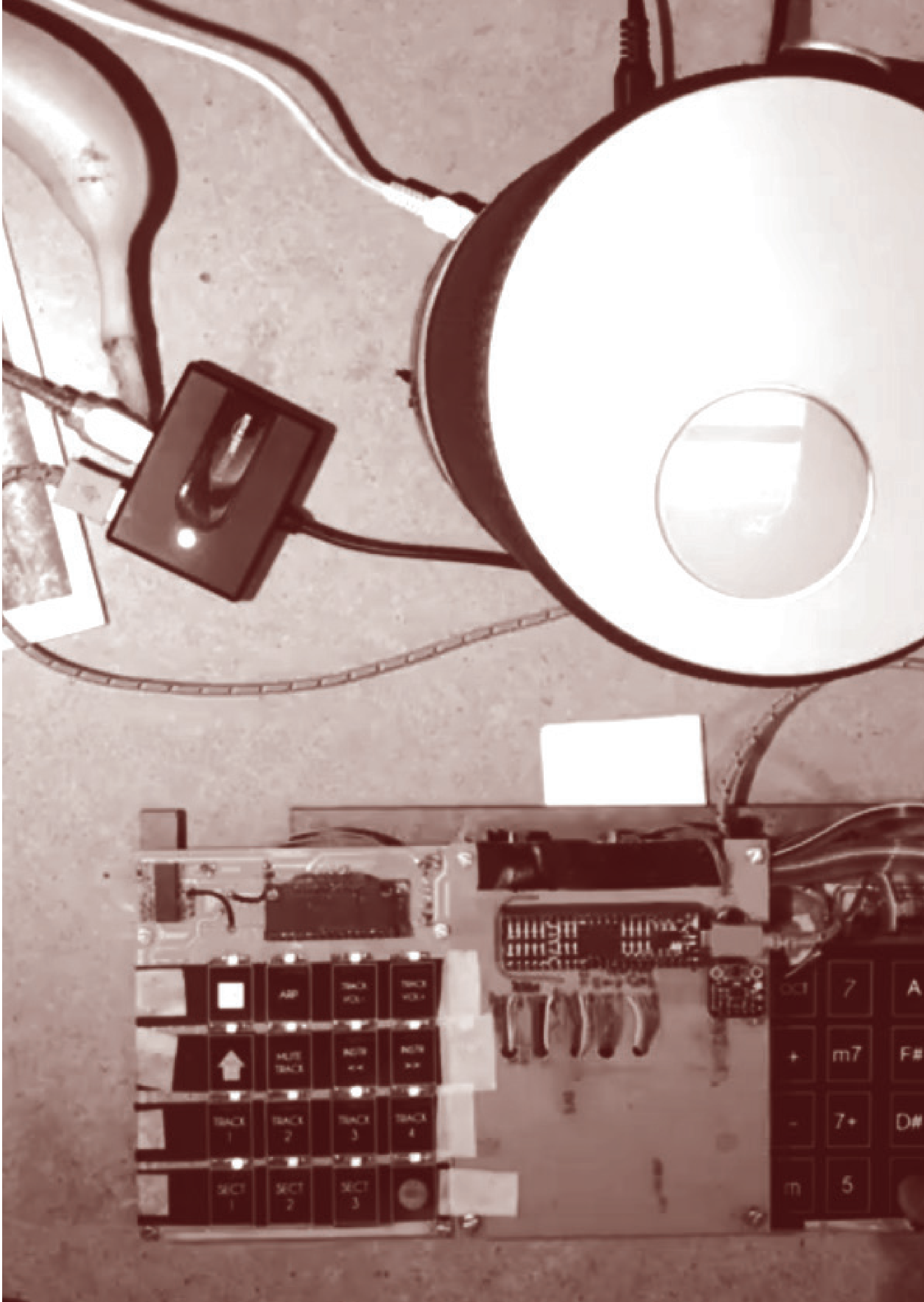
MusicFabrik: This diagram represents the connections which are part of the MusicFabrik engagement. Here we can see a person-to-sense of self and people-to-time. It has aspects of the Mechanics of Meaningfulness (Personal Development, Moments of Significance, Value over Function, Meaning in Everyday Life, Critical Thinking) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Everyday).



Credits
Concept, build and SketchyTuna development:
Antonio Stella
Baldur Kampmann
Martin Maunsbach
Martin Minovski
Nikolaj Ville-France
Supervision, concept and paper writing: Vanessa Julia Carpenter
Supervision and concept: Dan Overholt

Related publications:
(2018). Carpenter, V. J., Kampmann, B., Stella, A., Maunsbach, M., Minovski, M., Ville-France, N., & Overholt, D. (2018, September). MusicFabrik: a playable, portable speaker. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (pp. 701-705). ACM.

Møller, N., Overholt, D., Carpenter, V., Stella, A., Kampmann, B., Minovski, M. and Maunsbach, M. (2018). SketchyTuna: Exploring A Design For Screenless Creativity. Zenodo. http://doi.org/10.5281/zenodo.1422633.


ARP
MUTE TRACK
TRACK 1
TRACK 2
TRACK 3
TRACK 4
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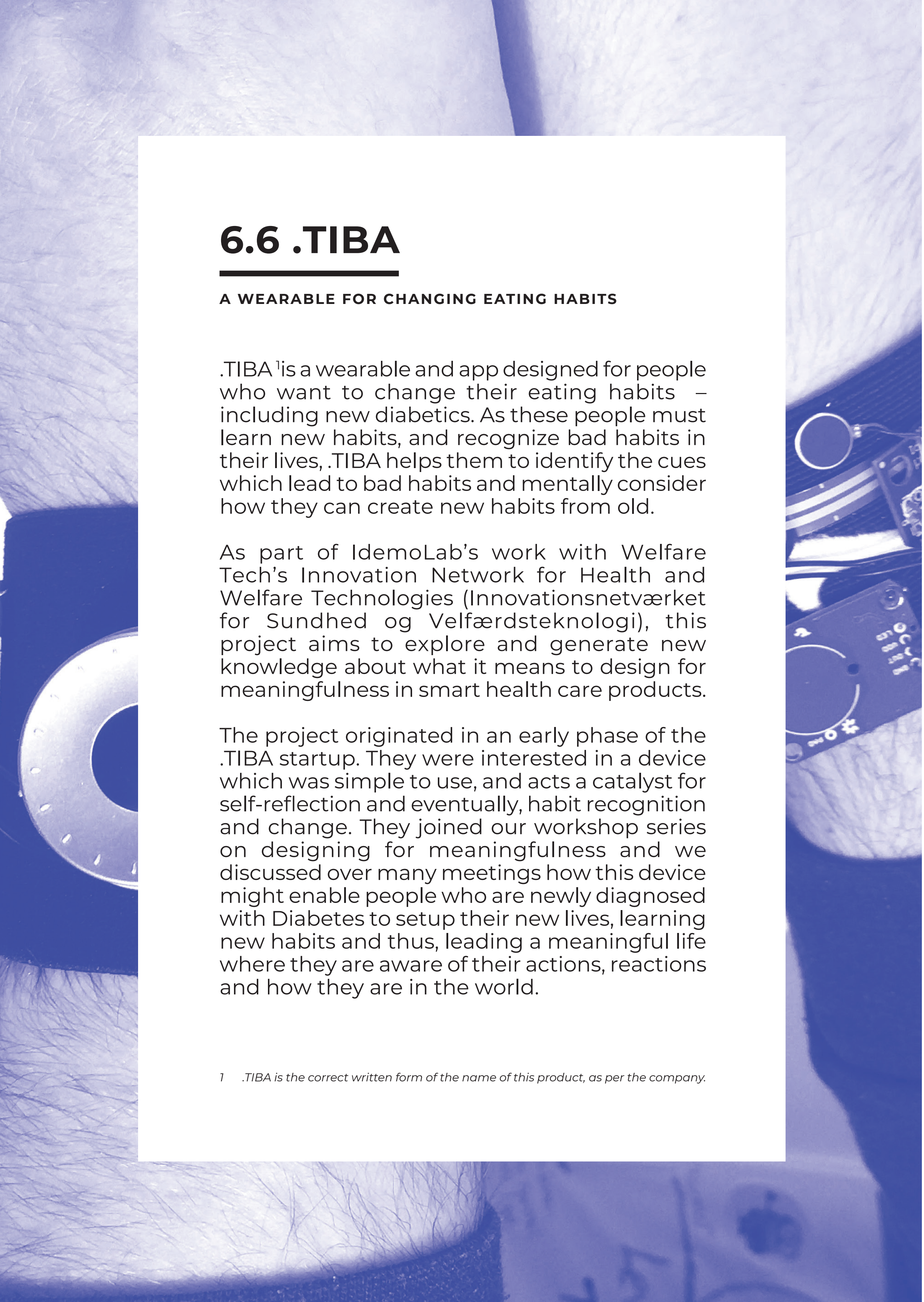


6.6 .TIBA

A WEARABLE FOR CHANGING EATING HABITS

.TIBA [1] is a wearable and app designed for people who want to change their eating habits – including new diabetics. As these people must learn new habits, and recognize bad habits in their lives, .TIBA helps them to identify the cues which lead to bad habits and mentally consider how they can create new habits from old.

As part of IdemoLab's work with Welfare Tech's Innovation Network for Health and Welfare Technologies (Innovationsnetværket for Sundhed og Velfærdsteknologi), this project aims to explore and generate new knowledge about what it means to design for meaningfulness in smart health care products.

The project originated in an early phase of the .TIBA startup. They were interested in a device which was simple to use, and acts a catalyst for self-reflection and eventually, habit recognition and change. They joined our workshop series on designing for meaningfulness and we discussed over many meetings how this device might enable people who are newly diagnosed with Diabetes to setup their new lives, learning new habits and thus, leading a meaningful life where they are aware of their actions, reactions and how they are in the world.

1 *.TIBA is the correct written form of the name of this product, as per the company.*

User scenario

A newly diagnosed Diabetic comes home after a long day of work. They are tired, and frustrated by their new diet and lifestyle. They sit on the couch, watching TV for some time. They feel like they are hungry, and then stop, pressing a button on the wearable. They then turn a dial to a specific stop point. They have just registered that they are experiencing a common trigger, feeling hungry when tired, and they have registered how intense that feeling is. They receive a text message with encouraging words, helping to keep them on track and then they go to bed, resolved to establish new, healthy habits.

Physical build

Originally, the device was a simple Bluetooth button (Flic.io) and a band for wearing around the wrist. Users could tap on the band and then report via a text message how high the intensity of the feeling was. IdemoLab conducted a workshop to evaluate and experiment with possible technologies the company could potentially pursue in terms of how input might happen such as via a soft button, a rotary wheel, or a capacitive touch interface. (Figure 15).

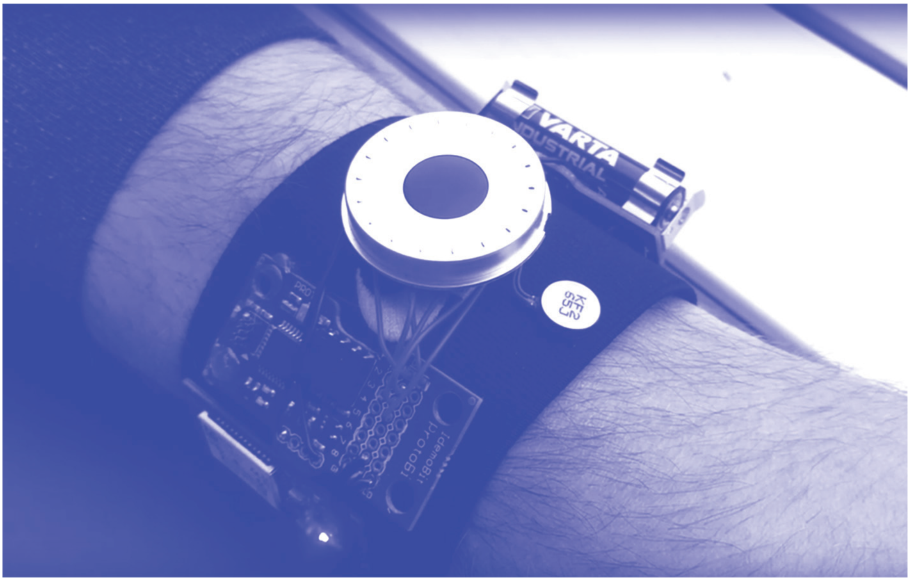


Figure 15 An early electronic sketch of .TIBA created by IdemoLab.:

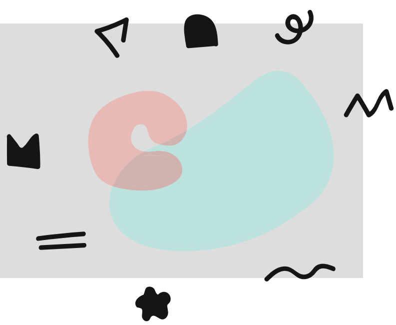
Manifestations of Meaningfulness

It was important to the company founders that we did not have a display on the wearable, that it act only as an input device. They were particularly interested in how to facilitate reflection and did not want to distract people with unnecessary information or operations. It is a non-screen device, and one which is felt. We were particularly intrigued by the rotary wheel concept where the person could turn the wheel, feeling and hearing the clicks of each level. We imagine in a future scenario that input would eventually become an experience where one did not have to look at the device but could simply feel where to move it to.

Mechanics of Meaningfulness

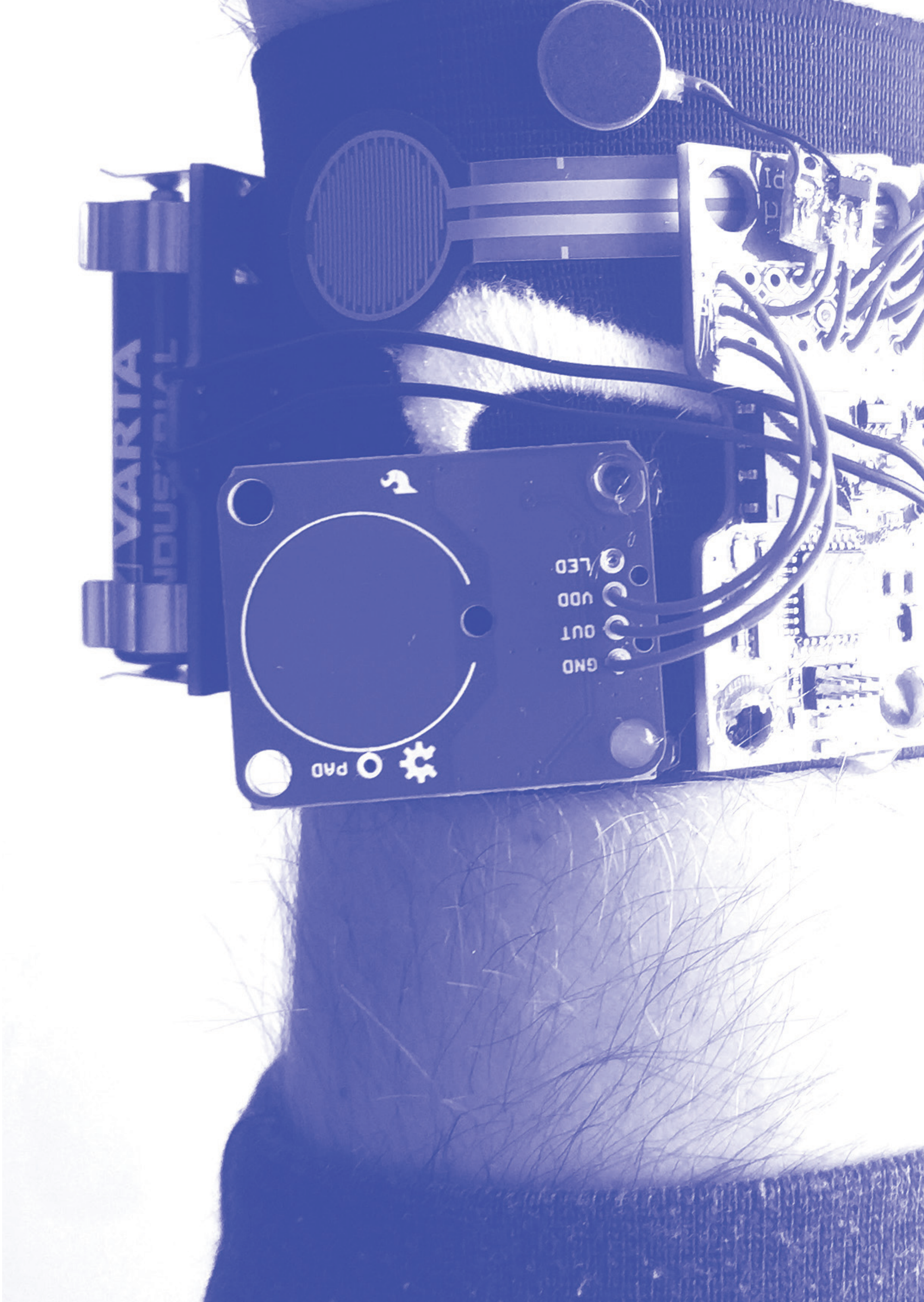
The aspect of critical reflection was important here, wherein the wearer must ask themselves, "am I really hungry, or just tired, and how tired?". Asking questions such as this, the wearer would come to know themselves and their habits better. This is a key attribute of designing for meaningfulness, coming to understand the self well enough to identify how and when a change is needed. This speaks to both personal development and critical reflection as well as moments of significance each time they realize that they are not in fact hungry, but just tired. That change might lead to meaningfulness: living a life that the person themselves decided upon, rather than being thrust into.

.TIBA: This diagram represents the connections which are part of the .TIBA engagement. Here we can see a person-to-sense of self and people-to-time. It has aspects of the Mechanics of Meaningfulness (Personal Development, Moments of Significance, Value over Function, Meaning in Everyday Life, Critical Thinking) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Everyday).



Credits
Michael Auchenberg, Co-founder, .TIBA
Tim Larcombe, Co-founder, .TIBA
Marcelo Halpern, PhD Candidate at Universidade Federal do Rio Grande do Sul (UFRGS)
Steffen Kjær, Specialist, Mikroelektronik, IdemoLab
Vanessa Carpenter, Lead Specialist, Technology Experience Design, Mikroelektronik, IdemoLab

The text from this engagement has been used to create a case study on the IdemoLab website as part of the requirements for the funding for the PhD with regards to the Welfare Technology Health and Welfare Technology network. https://idemolab.madebydelta.com/portfolio/habit/


VARTA
LED
VDD
OUT
GND
PAD

6.7 FROM SEX TOYS TO PLEASURE OBJECTS

Future Please Objects is an ongoing research project looking into how we relate to our bodies and our understanding and sense of pleasure. A group of researchers, artists and hackers has come together to debate and prototype early concepts of what a future pleasure object might be. Through three workshops in Copenhagen and Vienna, this group explored the stereotypes surrounding the concept of pleasure, and how people typically relate to it. From these discussions and debates emerged a common goal, to empower people to explore the concept of pleasure for themselves, and further, empowering them to use technology to do so. We envisioned a series of projects, created by artists, demonstrating a range of materials and interactions to enable people to explore what pleasure means for them.

These projects will eventually be made available in the form of Do-It-Yourself kits on an online platform, so that people can purchase the artist created kits, and explore them for themselves, in their own contexts. Further, a “Kit Zero” would be offered, a simple Arduino based platform for people to create their own interactions with the everyday objects and experiences they encounter which might represent pleasure for them.

Introduction

This project has been a two year exploration during my PhD, wherein we have conducted three workshops, two in Vienna, and one in Copenhagen. It has been described in the publication by Carpenter, Homewood, Overgaard and Wuschitz (2018). We were initially interested in what the future of sex toys might be, as they are currently heteronormative and more often than not, phallic in nature. We were interested in bringing together artists, hackers, creatives and and others to challenge this norm and explore the potentials. Through the three workshops, this concept was not only challenged but ended up on a parallel track (Redström, 2017) called Future Pleasure Objects.

Throughout the workshops, our definition of sexual objects expanded, together with workshop participants we investigated qualities of materiality and interaction, and discussed purpose, place, and the body, holistically. Our ambition is to create an online platform offering DIY kits to enable people to explore technology and pleasure.

Alongside redefining our idea to become Future Pleasure Objects, the three workshops generated three artistic works. These artistic works are beta versions of kits, and can be imagined to be kits of parts which enable people to build their own versions of these kits. The user scenario below will describe each of these three works. The paper written explores third wave feminism (Ahmed, 2017), as a foundation upon which we built this work, and using design anthropology (Gunn, Otto & Smith, 2013) as a method, how we moved from workshops to re-defining our concept.

User scenario - 3 Artistic Works

From our paper: “From Sex Toys to Pleasure Objects” (Carpenter, Homewood, Overgaard and Wuschitz, 2018) *Text Me* by Patricia Reis & Yara Bartel is a wearable device which does not rely on binary gender assumptions to operate. Instead, it focuses on the spine, where 12 vibration motors are triggered in varying patterns according to the content of text messages sent to the device. Reis and Bartel aim to facilitate a digital translation between body and mind, triggering body sensations via text message.“ (Figure 16).

Touching you/me with my breath by Patricia Reis is an interactive, non-visual device which aims to bring people together via breath, or allow someone to explore their own sense of pleasure via their own breath. As breath is sensed, a microcontroller translates the rhythm, intensity and humidity of the breath into vibration patterns using 10 motors on an adaptive textile belt. This piece is again, genderless in nature, and seeks to subvert visuality as the primary mode of experience as it stimulates the body.” (Figure 17).

Ardourino by Kristin Weissenberger, Günter Seyfried from Pavillon35 & Doris Roth from [kat]alab is an environmentally sensitive hydrogel which is reactive to electromagnetism. Ceramic vessels transfer the hydrogel on to the body, and an electromagnetic field is applied, activating the gel and creating sensations on the body. "

Physical build

As these are three different artistic works, I'll instead present here the future work of *Kit Zero*, an electronics DIY kit we are currently developing featuring four types of motors as vibration output and a 'anything is a touch surface' input (using the Touche Arduino Library). (Touche, 2018). Kit Zero is a simple kit, inspired by Perner-Wilson, Buechley and Satomi's "Kit-of-no-parts" (2010) which provides an opportunity for people to think about what works for them, and then implement it. Again, by referring to Future Pleasure Objects, it's any form of pleasurable contact. The output format of a vibration motor does not restrict the person to only vibration, they could attach that to a feather, and tickle themselves. The input of the feather tickler could be via stroking bowl, or a carpet, or anything else that the capacitive sensor might be attached to. The primary interest is in enabling people to utilize technology to explore their own bodies and their own pleasure, be it sexual or non-sexual.

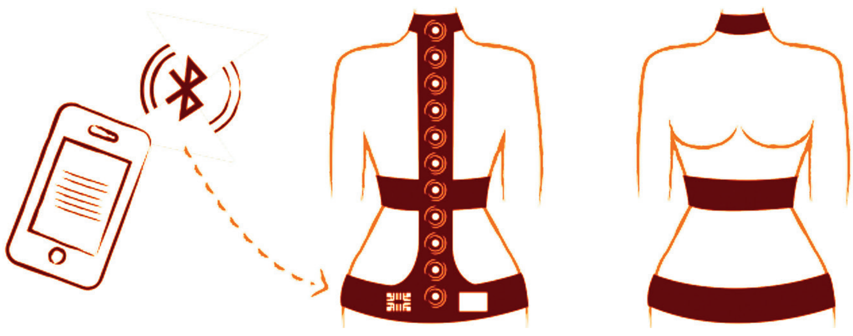


Figure 16: Text Me by Patricia Reis & Yara Bartel.

Manifestations of Meaningfulness

All three artistic works and Kit Zero utilize bodily engagement, and do not use visual stimulus as a means for input or output. *Text me* takes the concept of receiving digital information and translates this to a potentially pleasurable experience whereas *Touching you/me with my breath* does the same, but with breath as an input; and *Ardourino* moves in another direction completely, re-imagining how we relate to our bodies and technology through an unexpected interface, gel.

Mechanics of Meaningfulness

Designing for Future Pleasure Objects means addressing sexuality, gender, bodily awareness, and in the case of the kits, enabling people to create and explore. In this way, the emergent qualities of meaningfulness in everyday life and critical reflection are dominant.

People building these kits must first choose which kit they might be interested in, asking themselves which materials or experience they would like to explore. Secondly, they have to build and experiment with the kits, and it is here that I see how designing for meaningfulness emerges.

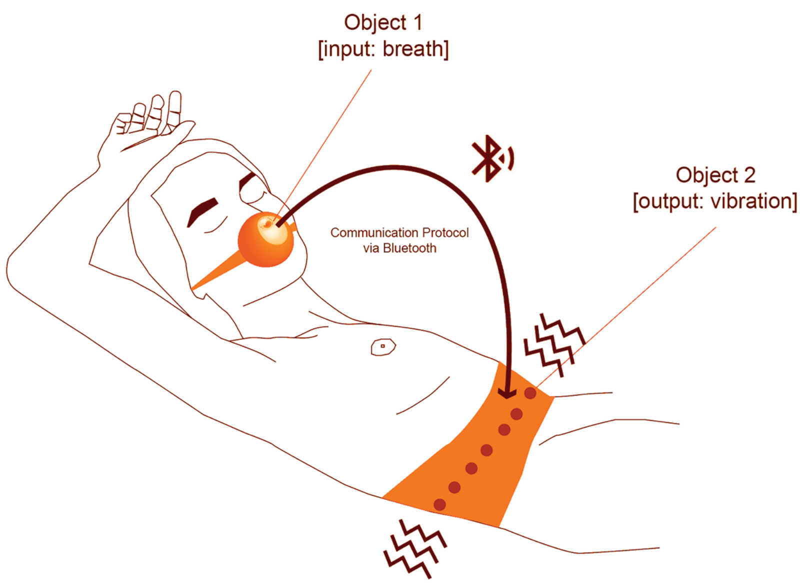
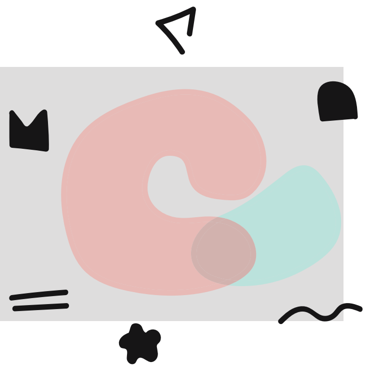


Figure 17: Touching you/me with my breath by Patricia Reis.

We are designing kits. These kits enable exploration. This exploration leads to critical reflection on needs, desires, and bodily experiences. Working with these kits enables meaningful moments in the everyday as people learn new skills (building the kits), learn about their bodies and learn about their responses.



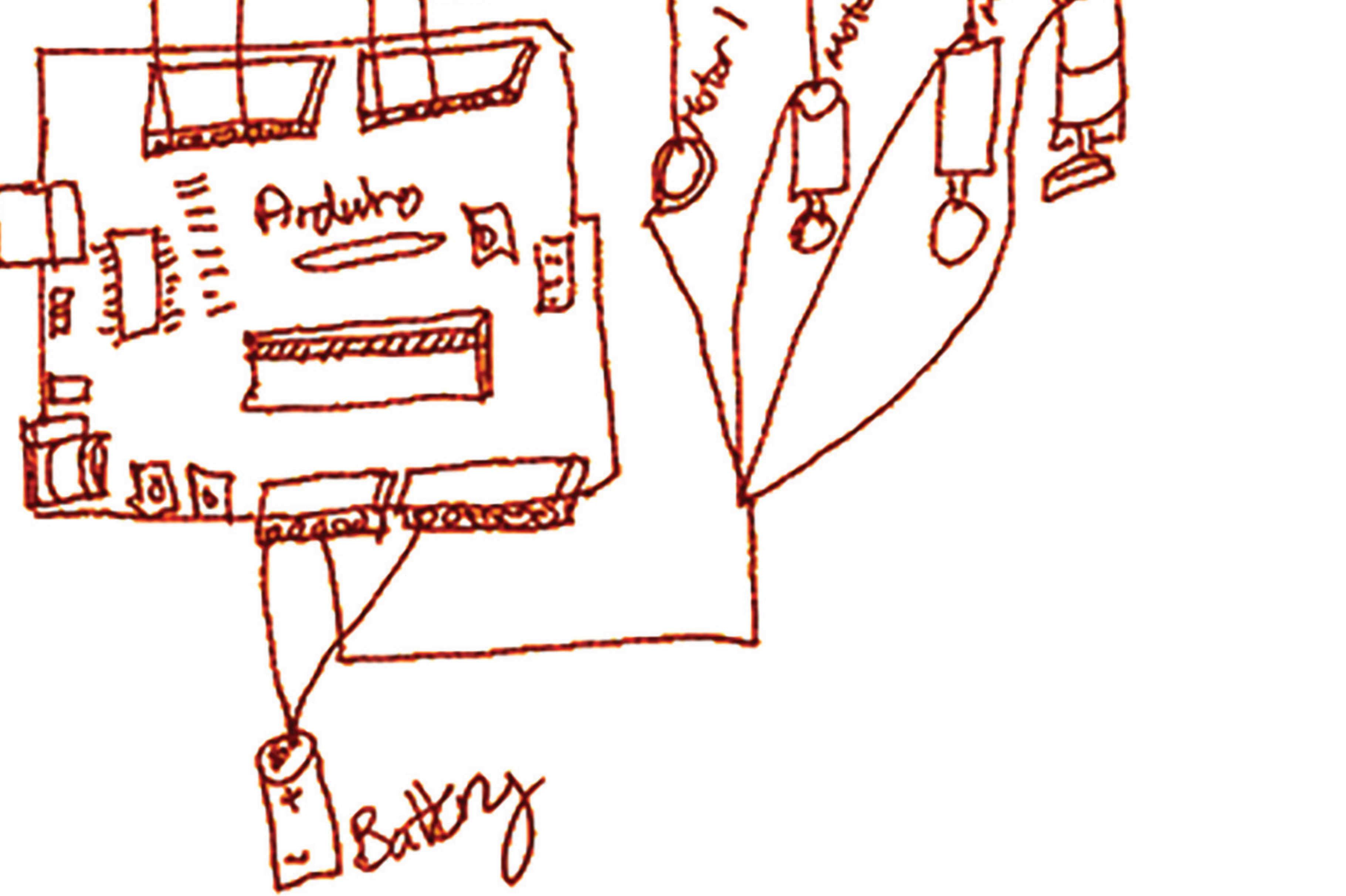
Future Pleasure Objects
This diagram represents the connections which are part of the Future Pleasure Objects engagement. Here we can see a person-to-sense of self and people-to-time. It has aspects of the Mechanics of Meaningfulness (Value over Function, Meaning in Everyday Life, Critical Thinking) and the Manifestations of Meaningfulness (Non-Screen, Tangible, Everyday).

Credits
Concept and workshop design:
Vanessa Julia Carpenter, Majken Overgaard, Becky Nelson

Artistic Works:
Text Me by Patricia Reis and Yara Bartel
Touching you/me with my breath by Patricia Reis
Ardourino by Kristin Weissenberger, Günter Seyfried from Pavillon35 & Doris Roth from [kat]alab

Research and academic paper by:
Vanessa Julia Carpenter, Majken Overgaard, Sarah Homewood and Stefanie Wuschitz

Related publication / Pending publication
(2018). Carpenter, Vanessa, Homewood, Sarah, Overgaard, Majken, & Wuschitz, Stefanie. From Sex Toys to Pleasure Objects. In Proceedings of the 2018 Politics of the Machine conference. British Computer Society.


Arduino
Motor 1
Battery

6.8 Synthesis of Mechanics and Manifestations of Meaningfulness

Figure 18 compares the Manifestations of Meaningfulness and the emergent Mechanics of Meaningfulness of each engagement.

It is difficult to state that 'certainly, this leads to personal development', however, the concept is to design *for* these qualities, to have them in mind when creating the eventual product. For some products, I have set an **X** as I do not immediately see the association to the ascribed quality. It is important to note that I do not suggest that designing for meaningfulness encompasses each and every physical characteristic or mechanic of meaningfulness. Instead these aspects act as parts of a whole, wherein the whole does not necessarily include every aspect. For example, Muscle Minder is not a 'crafted' object, it's part of a set of sports clothing or accessories and the craft aspect would not necessarily make sense here, it should eventually be practical, washable and durable.

I have set a **'?'** in areas wherein it may or may be considered to encompass that aspect. For example, with Fibo, it is not an everyday object, it is a wearable which is worn for only three months. However, it takes the form of a wrist worn wearable which is to some extent, an 'everyday' and very familiar object. For Electronic Kintsugi, it doesn't necessarily lead to critical thinking but it could, depending on how people engage with it, perhaps they use it as a meditation aid and then critically reflect on their lives.

Overall, most of these engagements do contain the majority of the aspects, however it is important to reiterate that these engagements were developed to explore, discover and demonstrate the aspects. They are not stand-alone exemplars of designing for meaningfulness. In Chapter 9 I present how the engagements lead to takeaways for designing for meaningfulness.

	Fibo	Electronic Kintsugi	Træk -vejret	Muscle Minder	Musik Fabrik	.TIBA	Future Pleasure Objects
Manifestations of Meaningfulness							
Non-Screen	✓	✓	✓	✓	✓	✓	✓
Tangible	✓	✓	✓	✓	✓	✓	✓
Craft	✓	✓	✓	✗	✗	✗	✓
Everyday	?	✓	✗	✓	✓	✓	✓
Mechanics of Meaningfulness							
Personal Development	✓	✓	✓	✓	✓	✓	?
Moments of Significance	✓	✓	✓	✗	✓	✓	?
Value over Function	✓	✓	✓	✓	✓	✓	✓
Meaning in Everyday	✓	✓	✓	✓	✓	✓	✓
Critical Thinking	✓	?	✓	✗	✓	✓	✓

Figure 18: Table: Synthesis of Mechanics and Manifestations of Meaningfulness across all engagements

7

INDUSTRY

7. RESEARCH CONDUCTED WITH COMPANIES

7.1 Overview

In this chapter, I present three long-format interviews conducted with Danish design companies; a series of worksheets presented at seminars; and a series of in-depth workshops conducted with welfare technology companies towards the end of this PhD period wherein we evaluated these companies' products in relation to the Mechanics of Meaningfulness, the Manifestations of Meaningfulness and 3 other “metrics of meaningfulness” as informed by other academic research and related projects.

7.2 Insights from Companies

Interviews & Workshops: Designing for Meaningfulness

To begin to understand how companies viewed and use the term ‘meaningfulness’ and what they thought about designing for meaningfulness, I set up a series of interviews with three traditional Danish design agencies and conducted a series of seminars wherein companies filled out a worksheet about their initial reactions to the term ‘meaningfulness’.

Lindström and Ståhl introduce the concept of temporary assemblies wherein members may know of each other from previous gatherings, but do not have a long history of gathering and discussing. Instead, temporary assemblies are a place to gather and facilitate conversations and share experiences (Lindström & Ståhl, 2012). The concept of a temporary assembly accurately represent how the sessions with companies occurred. These interviews were held informally as I have worked with these companies over the past 6 years and we are all familiar with each other but we have not formed a formal design-discussion group. Instead, they were kind enough to lend me their time and discuss the topic of meaningfulness with me. Below, I present a description of the worksheet given to other companies in an equally “temporary assembly” format, wherein a seminar about designing for meaningfulness was held and companies were asked to complete a simple worksheet. I then present the three long format interviews conducted, summarizing the discussion and presenting main points.

The format of the interviews was the same for both the design companies and the seminar workshops. I begin by asking those present to fill out a worksheet with their definition of meaningfulness. We then engaged in a longer dialogue: for the three design companies it was 1.5 hours and for seminars, it was roughly one hour including a 30 minute presentation.

My approach to this was to give the companies space to think about their relation to the term 'meaningfulness' and write down initial thoughts. We then held a discussion where for the most part, they spoke, and I listened in an unstructured interview format (Bjørner, 2015, p. 87). In the seminars, they debated amongst each other with me acting as moderator.

Worksheets

A worksheet was created to help explore what meaningfulness might mean for participants. An overview of the worksheet is presented, followed by a summary of the results. These worksheets have been distributed in the following meetings:

1. Workshop at IDA - the Engineering Society of Denmark about meaningfulness
2. Three one-on-one interviews with Danish design companies
3. Workshop about meaningfulness in health care products with five companies

Initial reactions to “meaningfulness” as a term

The worksheet asked about terminology (Figure 19). 5 boxes were presented, each with a title and several questions. Participants were instructed to note down their initial thoughts about meaningfulness in the span of 5 minutes. This exercise was meant to extract their initial reactions and associations to the term meaningfulness and to have something to refer to during the remainder of the session. It should be noted that participants were invited to use their language of choice, either Danish or English to facilitate fluency from thought to paper. Danish responses have been translated. The five questions included:

1. Personally: What does the term meaningfulness mean to you?
2. Experience: What are meaningful experiences?
3. Your Terms: Do you use the term meaningful or meaningfulness in your design process?
4. Keywords: What are some keywords you associate to meaningfulness or meaningful experiences?
5. What did we miss?

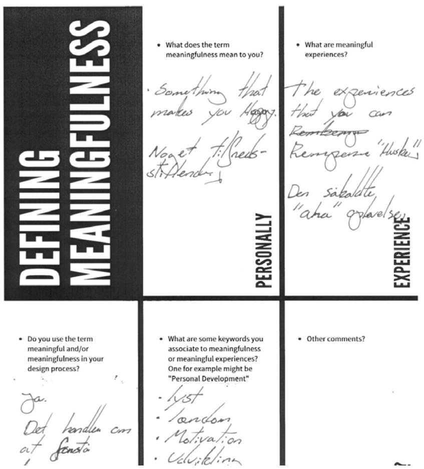


Figure 19: Example worksheet from the meaningfulness workshop at IDA.

A summary of answers provided is described here. Quotations refer to paraphrased quotes as some have been translated from Danish. In total, 10 companies filled out these worksheets.

Personally: What does the term meaningfulness mean to you?
The word 'purpose' appeared repeatedly, with 'profound, worth, useful' and a particular highlight on personal importance. One participant noted that meaningfulness personally was something that makes you happy, and another noted "something that I actually want to use and not just put away". Some connected it with a positive experience and happiness. One further commented "It's something that makes a positive, (hopefully) enduring positive impact in people's lives. Something that makes a difference". Another mentioned that "It means a deep purpose, sometimes beyond rationality".

Experience: What are meaningful experiences?
The main objective of this chapter was to try and give a short format answer to a long and tough question. Some of the shorter form answers included the term 'memorable' or experiences wherein you have an 'aha' moment. A few participants wrote just one thought, such as "An experience that changes me in some way" or "These are those experiences that have this positive impact. They create value in people's lives." or "A meaningful experience resonates with a person's feeling of purpose. It can also be one that creates a new discovered purpose". One participant expanded on the idea of something memorable and stated that a meaningful experience creates memories and "teaches you something about yourself". And one participant highlighted the importance of the subjective aspect, "personal experiences that might not mean anything to others but means a lot to me".

Your Terms: Do you use the term meaningful or meaningfulness in your design process?
Unfortunately I didn't realize the binary nature of this question until too late, so for most of the worksheets, participants wrote "yes". However, some elaborated: " Yes, I usually try to create meaning/value for the target group I am designing for" and "I have not used the term "meaningful". However I have been working with it subconsciously. Often in regards to creating a deep relation between human and product". For one participant, they replied " No I mostly use 'personal'".

Keywords: What are some keywords you associate to meaningfulness or meaningful experiences?
Here the answers varied considerably and included: individuality, motivation, development, experience, purpose, change of habits, useful, growth, worthwhile, impact, value, use-worthy, helping, action equals reaction. Of these, 'motivation' and 'experience' came up in several worksheets.

What did we miss?
There was only one comment left for this chapter throughout all the workshops and that was ‘money’.

From the replies it can be summarized that a positive, memorable, personalized experience, which helps with personal development, and contributes to a sense of purpose is how companies relate to the term meaningfulness. This relates strongly to the Mechanics of Meaningfulness. The interviews following get more into depth with three companies about how they relate to meaningfulness in their design agencies.

7.3 Group Workshop

A workshop was held in collaboration with the Engineering Society of Denmark (IDA) around the topic of designing for meaningfulness (IDA, 2017). The focus group (Bjørner, 2015) consisted of 8 people, both from small-medium enterprises in industry and some who were students in technology domains. I introduced my perspective on designing for meaningfulness and then the focus group participated in a debate about what designing for meaningfulness might entail.

One theme was what *kind* of product something is - personal, or impersonal. A toothbrush was given as an example of something that is practical and personal: you’re the only one using it, but it’s not a personal, emotionally charged object. Another aspect entirely, brand identity, arose as a topic of discussion and the question “how much of the meaningfulness comes from the design of the product and how much from the brand?” was asked. We discussed a FitBit, which has an extensive ecosystem: essentially it tracks your steps, however it’s also connected to a social platform, a wake-up alarm and nudging system, and increasingly, more features such as heart rate and breathing. We compared this to a product which contributes to a cause, such as Tom’s shoes [1], where when one pair of Tom’s are purchased, then another pair is given to someone in need. These have aspects of meaningfulness but in very different ways, and are branded quite differently. FitBit is a health and wellness device aimed at people who want to improve their physical lives; Toms are aimed at people who either like a simple shoe, or those who know the story behind Toms and buy them from a conscience shopping perspective.

One of the conclusions of this workshop was that there needs to be trust in a product. One participant stated: “It should make us feel good and it should be established over time. We should have a good relationship with customers.” This speaks to the time aspect of meaningfulness, that it is established over time. Another participant commented that “interaction and relationship are very important factors in the social era we live in right now. We need to shine

1 *https://www.toms.com/*

there and make things interesting" and another said:

> "I found it really interesting, the two sidedness of meaningfulness, the more rational side and the other one which you explain and feel its meaning and the fluency of meaningfulness."

The dual aspects of social interaction (relation) with interaction, alongside rational versus emotional qualities are of note. The people-to-people or person-to-sense of self aspects of meaningfulness which I highlight in this dissertation combined with an appreciation of the rational, practical nature of the physical qualities or the usefulness of a sketch or product are an interesting balance to maintain.

The outcome of this is a multi-faceted view of what designing for meaningfulness means for different companies and individuals. Some are focused on the brand message of the effect of the product, whether personally or on a societal scale; some were mainly interested in how the product affected relations between people and within society, and some were fascinated by the explorative nature of the term 'meaningfulness'.

All views highlighted the complex nature of the three aspects: people-to-people, person-to-sense of self and person-to-time.

7.4 Interviews

Three Danish design companies with whom I have collaborated in the past were interviewed using an unstructured interview format where we conversed about how they relate to meaningfulness in their work.

A summary of each interview is provided below without identifying the companies to maintain their anonymity as they discuss their customer projects and experiences.

Following this, a discussion of the findings from these interviews is presented. All text in quotations are quotes from the interviews, either direct, verbatim quotes and also summarized, paraphrased quotes from a longer answer.

Interview 1:

This design company has a 40 year history as a landmark in Danish design, working from both an angle of user centered design and context as well as industrial and graphic design. The following interview was held with the two directors of the company.

One of our main discussion points was, interestingly, toilets. I had asked them to exemplify one of their designs which they felt was representative of meaningfulness and they pointed out a classic toilet design. “You see it everyday, you never feel like something is wrong”. They talked about how the aspects of hygiene and privacy are important here, and how as soon as you don’t have it, you realize how meaningful it is. This is where our definitions of meaningfulness differed. We discussed a meaningful experience, in terms of life fulfilment, personal development, critical thinking, etc, and compared this to the toilet. This was another example of meaningfulness, the toilet is meaningful because it holds a lot of value in one’s life, but that isn’t the same as it facilitating meaningfulness.

Side note:

> *A common response from companies is that their products are of course, meaningful and I cannot argue with this, but as far as facilitating meaningfulness, that’s something else. Another company I spoke with said their product was meaningful because it was safe to play on for children and would last a long time. They commented “My idea of a meaningful design is one that is useable in practice” referring to the durability and ruggedness of their product. This is not the definition of meaningfulness which I refer to and is an important distinction in this chapter as I drill down to what I do mean by designing for meaningfulness in the next chapter.*

The design company and I discussed quantified self in terms of fitness tracking wearables. I was wearing a simple Nokia Steel watch whose second hand shows the percentage of steps taken for the day and one of the designers was wearing a Garmin health tracking watch. He explained that it provides insights, such as how much more you moved today than yesterday or how much more than other people your age. We discussed how these insights could lead to meaningfulness through reflection and action, taking more steps after the insights provided by Garmin, as an example. We debated the difference between my non-screen Nokia Steel, which is a glanceable device, requiring only to see the second watch hand to see movement progress, whereas his Garmin is a screen, requiring interaction to access the various insights. Both had their merits and the value over function aspect of insight and motivation was the key factor for both.

Our conversation turned to mobile devices, and how they have replaced the clock, the radio, the answering machine and cameras, as a few examples. Interestingly, this design company focuses on making objects which we use everyday, physical objects: tables, lights, toilets, chairs. They explained how we still need physical objects in our lives and perhaps in the future, some of them might be smarter, such as the toilet.
Finally we discussed how to help others design for meaningfulness and they suggested hiring an anthropologist because “an anthropologist has the tools to observe and think first and incorporate function into an everyday lifestyle”.

Interview 1: Summary

This interview as interesting as it showed the distinction between a meaningful object and designing for a meaningful experience and a meaningful life. A toilet is meaningful, it is necessary and aspects of it are important, comfort, hygiene, ease of use. But it is not necessarily facilitating a meaningful experience or adding to a meaningful life. However, the aspect of physical objects in a world with increasingly digital experiences was of value and it is interesting how design in this context.

Interview 2:

A younger but well established design company, this company focuses on the interdisciplinary qualities of collaboration with roles ranging from industrial and UX design, to business, to engineering and production. They have a range of customers and a common underlying principle: user centered design. This interview was with the founder of the company, who commented: "Wow. That was smart". The CEO believes that if he really feels a product is well designed, he'll think, "wow, that was smart". We discussed how technology and design should enhance each other, and that the role of technology is not to be present as technology, but rather to ask what it can provide or replace. He emphasized that technology and a simple solution is the key to happiness; and he is especially concerned with who is going to use a given device. As a company, they try not to judge clients, but they do have some guiding principles such as that they will not work on weapons. In saying this, the CEO pointed out that they do in some way, judge their clients in that they are trying to help them to re-evaluate and think of things in a different way, always asking WHY in relation to the business case. They approach cases strategically, looking at the development of the company, the politics, the investors, and where they want their focus to be.

We discussed the role of objects in design versus apps, and the CEO stated how he might feel about a new smart product: "If it's another app, then I don't feel comfortable about that. Then you have to be in your smartphone again and then you are bringing yourself out of the moment that you are facing. If it is something you have on your desk, it could be more intuitive, but if you have to interact with your smartphone then it's at least 3 steps before you're entering that app." This is supportive of the non-screen approach I am interested in as part of this research.

Finally, as they are going from concept to on-market product, there is a substantial combination of stakeholders and they need to consider everyone along the way. The CEO mentioned that for him, a sophisticated process is fascinating, finding out how everything works together to create the final product.

Interview 2: Summary
This interview offered some key points regarding technology and design and how to think about the business aspects such as the various stakeholders. Ultimately, designing for meaningfulness concerns the person who eventually uses the product, and the design decisions along the way are significant in terms of the final experience and how it is interpreted. Finally, a particular point of note was the comment about smartphones and the interactivity required to engage with a smartphone. This is an important argument towards my identification of non-screen as one of the Manifestations of Meaningfulness.

Interview 3:

This design company has existed for more than 25 years and has been involved in a number of projects with both consumer facing and industry facing challenges. They are recognized for their work with industrial design and sustainable development. This interview was with their design psychologist who began by stating:

> “Our embodied experience with the world helps us to understand how we should interact with digital interfaces”

We discussed the rationality of thinking versus the action of actually doing things and how for this company, interaction design is a question about how one can take a complicated technological device and make it understandable for people who have little technical insight. They focus on how they can mimic how the world is already designed to help people adapt to technological devices.

“We are evolutionary beings, what we are really good at is interacting in the physical world. It comes naturally to us, in most situations and we don’t think much about how easy it is to walk up the stairs, or go home, you might not even remember taking the trip because you’re thinking about something else. But it’s so hard to make a robot do this.” From this we discussed how the knowledge and skill in our bodies can’t be explained that it is like “describing to someone how to ride a bike, it’s not the kind of knowledge we have reflective access to” and that this embodiment is a part of being human, and contributes to meaningful experiences.

Furthermore, our interaction with the physical world is a major part of how we understand it, “When you have a physical interface you get feedback, such as the difference between physical buttons or buttons on a screen. With a physical object you know you’ve done something, with a button on a screen, there’s hopefully something visual to inform you that you’ve done something. It’s basic perceptual systems, if I’m interacting with the physical world there’s going to be some feedback..."

(the designer knocks on the table)
"...it's how we understand the world, it's part of being able to function in the physical world."

We also spoke about identity, how a device which enables meaningful experiences might be one which helps build identity. We used a simple example of a pen, "If we should look at the history, the sense of self, maybe this is a pen I used when I was a kid, or this one had a special meaning, maybe it was used to sign a peace treaty, it has some sort of significance, personal or cultural." We discussed that the personal significance, or the cultural or historical significance would affect how we interpret how meaningful an object or experience is, and our very understanding of whether or not it is meaningful is tied into those parameters of identity - historical, personal or cultural.

We also discussed the aspect of storytelling, how an object might enable a story to be told, or a new story to be formed, and how "choosing something from this design company tells a story of design tradition, it's an issue of quality, the materials used, natural materials." The combination of the physical form, the materials, the function and the historical, cultural and personal associations contribute to a sense of meaningfulness.

We discussed an example of a backpack which doubles as a picnic set. The designer explained the form of the backpack, "If you sit someone down who has never seen a backpack, and it fulfils a goal they have, carry things from a to b, it's an object that makes sense." and then we discussed how the picnic aspect of it, that it folds out to be a table, makes it easier to have a social gathering with friends and family. It's both functional and provokes this experience to happen. It becomes a reminder for doing something nice. It's about the association to the picnic, it triggers an action. The object comes to embody the whole experience. From this we moved on to a set of children's stilts, which the designer described as a "good example of a meaningful object", since it evokes action, "this makes me express my body and do fun things and learn things".

Interview 3: Summary

The aspects of identity, storytelling and and knowledge production were important in this interview. While the company doesn't explicitly design for meaningfulness, they do so implicitly, focusing on the lives of the people who use their products and the history, associations, stories, actions and behaviours that might affect how the product is received, used, and kept (or not). These values of personal development, identity, self, physical form, and triggering of action (affordances) are all vital aspects when I begin to discuss the Mechanics of Meaningfulness.

Learnings from interviews

These interviews were an interesting aspect of the research. As they were conducted with successful Danish design studios, it was relevant to hear their take on meaningfulness as a concept as they would ultimately be collaborators when creating future smart products designed for meaningful experiences.

As they have experience in designing not only the form, but the intended experience of a product, their input was important for me to understand how they related to my ideas, and what further ideas I might get from them. Concepts such as the need for physical objects in an increasingly digital world were popular, and this speaks to my focus on non-screen, tangible interaction, and the use of traditional craft and everyday objects. Then more value based comments such as those about the growth of identity, the use of storytelling, the exploration of personal significance, these are reflected in the Mechanics of Meaningfulness.

While my own engagements were created in the spirit of Buxton's sketches (2007) as early, functional prototypes, the role of aesthetics in these design companies and industrial design choices, such as material choice, were reflected in my work, such as the decision to make "Trækvejret" out of natural materials, or to reflect on the role of Japanese traditional craft in the Electronic Kintsugi. As the interviews were done within the first year of the PhD, I imagine that these conversations also contributed to my lens of what meaningfulness is, and what it can be.

7.5 One-on-one Workshops:

Meaningfulness as Experience

As part of the work done within IdemoLab for designing for meaningfulness, funding was provided by Welfare Tech, a health-tech cluster to explore designing for meaningfulness in health care. IdemoLab thus conducted 9 workshops with welfare technology companies. Each workshop was two hours long, and we asked them about their relationship to the concept of meaningfulness in their products through the use of questionnaires in interview form, written form and Likert scales (Brooke, 1996). The workshops are described in "Towards Metrics of Meaningfulness for Tech Practitioners" (Carpenter and Mekler, 2019).

The companies ranged from those with no technology currently present in their products (but who might consider it in the future) to those with a device. Some were focused entirely on having a utilitarian device and therefore, the sense of designing for meaningfulness as I present it in this dissertation did not apply to them or their product, and for some, this sense of meaningfulness was at the core of their product.

These workshops were designed with Dr. Elisa Mekler, the Research Director at the Human-Computer Research Group, Center for Cognitive Psychology and Methodology in Basel. Dr. Mekler is also studying meaningfulness in relation to technology and we saw this as an opportunity to engage industry in evaluating our collective understandings of meaningfulness.

In designing these workshops, Dr. Mekler and I aimed to explore both of our understandings of meaningfulness and compare these to others via a real-life response from companies to the aspects of meaningfulness. We therefore prepared a series of questions, which we collectively called the Metrics of Meaningfulness, which can be seen in Appendix 1 and included:

- The Mechanics of Meaningfulness (my own work)
- The Manifestations of Meaningfulness of meaningfulness (my own work)
- Components of the Experience of Meaning (from Dr. Mekler's work)
- The "BetterThings" questions (from http://betterthin.gs/)
- The HEMA questions about eudaimonic experience (Huta & Ryan, 2010)
- The Meaning as a Subjective Experience questions (Huta, 2017)

The workshop format was two hours in which we spent 1.5 hours moving through the worksheets. A full explanation of the workshops can be read in the submitted work, "Towards Metrics of Meaningfulness for Tech Practitioners" (Carpenter and Mekler, 2019).

The 9 companies were part of a welfare technology innovation network so all are offering health care products designed to be purchased by the municipality for the use of citizens who are in need of such products. A classic example of such a welfare technology product is a fall detection system. A description of each of the companies' products is provided below.

The format of the workshop was to first do an introduction round wherein the companies introduced themselves and I introduced both IdemoLab, FORCE Technology and the Mechanics of Meaningfulness and the Manifestations of Meaningfulness. This was done via introducing Fibo, the pregnancy wearable as a case study, demonstrating each of the mechanics and how it did or did not follow the Manifestations of Meaningfulness. I acted as a presenter, and then as a note taker. One of my colleagues with a background in design research acted as an impartial interviewer, leading the company through each worksheet. In total there were 6 worksheets (with worksheet 2 being two worksheets on one page. These are presented in 7.5.1, below.

The companies participating have the following products. This list has been anonymized here as not *all* companies wanted to be published. Those that did are quoted in (Carpenter and Mekler, 2019).

1. A feeding robot and assistive arm
2. A system of interactive 'spots' which are round, durable plastic discs used for physical interaction
3. A series of assistive chairs to help caregivers in elderly homes to assist the citizens and prevent injury to themselves.
4. An online network to allow people who are seeking companionship to find others and create relationships. Many of the users are experiencing profound loneliness, stigmatization, or disease and are seeking relationship and understanding from others who have experienced this and can help them.
5. A series of sensory stimulant and calming textiles which allow people with anxiety, autism, or similar to lead a more social life, or even to exit their homes.
6. An intelligent medicine box which offers a button to record when medication has been taken and provides alerts to caretakers or family when medicine is forgotten.
7. A system of mechanical products to help people ascend stairs, whether they have difficulty walking or are in a wheelchair.
8. An activity monitoring device for patients with dementia in care homes to monitor their day rhythms and help them to overcome sleeping problems.
9. A wearable alarm for the elderly which calls a caregiver in case of emergency

Ambition

Our ambition with these workshops was threefold: firstly, to offer to customers a way for them to reflect about their product and to consider what meaningfulness means in their case; secondly to gain insight into how customers responded to the different types of worksheets and descriptions of meaningfulness by comparing the responses to the various researchers' approach to meaningfulness; and thirdly, to determine if this would be an interesting future service offering for FORCE Technology.

My personal interest was primarily in how the customers responded to the Mechanics of Meaningfulness and the Manifestations of Meaningfulness, and whether these suited their product. Since my focus has been on 'smart' consumer devices and all the companies participating primarily make aid devices which are sold to the municipality to help people in their homes, these cannot be considered consumer devices in the same way. Further, in regards to the 'smart' aspect, some have technology built in and are interactive and some do not. Some were for the ease of the caretaker or the municipality, to save them time and money while others were used by the citizen in their home (note: citizen is preferred to patient as for some, there is no disease or illness present, sometimes it is a physical challenge, or an aid mechanism, such as the intelligent pillbox).

For the citizen, these products were not necessarily personal in the same sense as something like Fibo, which is a personal device, or such as Trækvejret, with which one personally engages. Instead, these were often products which helped them at some point during their day. This was an interesting observation, and related back to the aspect of time and the temporality of interaction with these devices. In the case of the sense stimulating / calming textile, a person might utilize it before leaving the house to build up energy to enter the outside world, or use it when coming home to unwind. In this way, it is a personal product, based on a timely interaction of preparing for, or recovering from, interaction. This aspect of time (one of the takeaways from this dissertation) is of particular interest for these welfare technology products.

Findings

As nine companies were interviewed for two hours each, there is significant material. To provide an overview, I first present a brief reflection on the reaction to the different approaches to meaningfulness, generalized across the companies.

Mechanics of Meaningfulness

Companies chose two Mechanics of Meaningfulness to discuss since we did not have time to discuss all five. We were also interested in which two the companies would choose. Interestingly, companies primarily focused on "Value over function" and "Meaningfulness in everyday life" with these getting the majority of selection, and one choosing "Moment of significance" and two choosing "How does it establish personal values?". "Personal Development" and "Critical Reflection" received no selections from the companies which might be a reflection of the fact that all the companies were health care based and not personal consumer devices. Companies spent time considering how their product related to these mechanics, for example: value over function. Although some had function as their primary sales point, they often had an answer ready for value, such as injury reduction in the long term, or creating a feeling of safety. The majority of companies chose "Meaningfulness in everyday life" as their products are used everyday. One company explained about their product "It only works if you wear it everyday and so it has to be meaningful enough to wear everyday".

Manifestations of Meaningfulness

Despite a variance of products from robotic arms to weighted blankets to wheelchairs, there was a consistency in answers. Most companies had no screen (with the one exception of the online portal for companionship) or they had a product where a screen was a secondary interaction mode. Most of the products were considered tangible and they were engaging with the physical body. All were considered 'everyday', used on an everyday basis and important for everyday function and health. Few were considered craft and these companies tried to relate craft to industrial design, but ultimately it was only the weighted textiles and the wearable alarm which actually had engaged crafts persons (such as jewellery designers for the alarm) in their process.

Components of the Experience of Meaning

Although companies did not focus on ‘moments of significance’ or ‘personal values’ from the Mechanics of Meaningfulness chapter, they were asked about it in this chapter and for the most part, answered thoroughly. Mekler and Hornbæk asked about *purpose* - achieving one’s goals, about *coherence* - how the product makes sense to the user in their lives, and about *significance* - does the product matter to the user longer than the momentary interaction?

Companies had varying responses depending on their product however the majority focused on the personal goals of maintaining independence or self reliance (such as feeding oneself). In some cases, companies agreed that their product was clear coherence wise (as for some, it might be an aid that they simply need and they don’t need to understand the technology or infrastructure behind the product). And companies stated their products were generally significant to the citizen in some way, such as in the case of the chair where it was most significant to the caregiver who was not getting injured, or to the municipality who was saving money on not having injuries.

Better Things

As previously introduced in this dissertation (Chapter 5.2), Better Things is a conceptual service by industrial designer Noam Zomerfeld. Participants answered the ‘meaningfulness’ questions from Better Things in a ten minute, silent work session. This was to provide a break between interviewing sessions and give some time for reflection. Some of the most abstract questions yielded interesting results. For the interactive spots product, they described a “sense of wonder” when stepping on the spots; the online companionship portal described how people finding new friends is a form of art. On the other hand, asking how it is essential or how it solved a problem yielded more straightforward answers such as from the assistive chair company who wrote: “otherwise you can’t get to the toilet”.

Scales of Meaningfulness

We used two sets of questions from others’ research: the HEMA questions about eudaimonic experience (Huta & Ryan, 2010) and the Meaningfulness Experience Scale (Huta, 2017). We presented the terms here as Likert scales with a rating from 1 - 10 with 10 being most in agreement. We asked participants to explain their choice of rating for each. We had some trouble with these as many of the terms were similar to each other such as “precious” “something you treasure” “something dear to me” or “seeking pleasure”, “seeking enjoyment” or “seeking fun”. We surmised that the confusion was due to both a language difference (English versus Danish) and because the overall context was missing (companies had not read Huta's papers before the session, nor had they necessarily studied philosophy or psychology) not to mention that the nuances between some of the terms was minimal and required some consideration, such as what is pleasure versus enjoyment? Overall, it was most difficult to get interesting responses from this exercise. Participants did try to explain their choices and sometimes we got some interesting responses such as the Dementia activity monitor company who rated Enjoyment as a 3 out of 10, stating "it's not a game, it's a tool" and rated "Treasure" as an 8, because one might treasure it as a professional tool which truly helps them do a better job.

Summary

Companies responded very well to these workshops. Not only did they each spend approximately 10 hours of their time preparing, commuting and participating, they also reported that designing for meaningfulness was an important consideration for their product development. This is an important indicator of how designing for meaningfulness is relevant and timely for industry. I discuss this further in Chapter 10: Discussion and the quotes below from companies further exemplify the companies' interest.

The companies commented, "It was a great pleasure and I look forward to hear what the future brings when meaningful design is a part of product development" ("Det var en stor fornøjelse og jeg glæder mig til at høre hvad fremtiden bringer når den indeholder meningsfuldt design for virksomheder og produktudviklere") and "Thank you for some great hours, reflective thinking and good feedback on our product" ("Også tak herfra for nogle spændende timer, reflekterende tanker og god feedback på vores produkt."). "It was really interesting, we certainly got some tools we can use moving forward" ("Det var rigtig spændende, jeg tror bestemt vi har fået nogle værktøjer vi kan bruge fremadrettet.").

We found that companies were very thoughtful about their answers in the workshops, and truly challenged themselves in whether or not their products offered for example, more value over function, or whether they help users identify personally important goals, or if they had considered including traditional craft in their product.

These type of reflections led to interesting anecdotes wherein we were able to hear a different perspective of designing for meaningfulness, namely the aspect of how a product designer views their existing product, and reflects on the intentions of that product.

We also encountered that in welfare technology there is always three users: the municipality (the payer), the caregiver, and the citizen (or patient). It was always a struggle to identify which user group we should focus on when discussing designing for meaningfulness, but once this discussion had taken place, then it was much easier to say for example, in the case of the online companionship portal, the municipality was able to see a benefit from people not being so lonely, and people (the citizens) developed personally, creating new relationships, and fulfilling personal goals, finding significance in their interactions. In this case, the meaningfulness exists for the citizen, and the municipality was able to feel it was 'meaningful' in a sense, as it reduces their expenses.

This workshop series demonstrated how companies found designing for meaningfulness useful and relevant to their work, even when they didn't necessarily design smart consumer devices. As companies were reflecting on the experiences and feedback they have had on their existing products as well as considering their intentions with their product, we were able to hear how these existing 'users' might consider their products to offer a meaningful experience.

Interestingly, most companies rated their product or service a '10' when asked if it was meaningful. As discussed in "Towards Metrics of Meaningfulness for Tech Practitioners" (Carpenter and Mekler, 2019) we find this interesting, and supportive of the need for Metrics of Meaningfulness which address the nuances of meaningfulness, such as the Mechanics or Manifestations of Meaningfulness. Essentially, it is important to ask more than simply, "Is it meaningful?" because the answer will always be "yes".

All companies agreed that designing for meaningfulness could be a service which FORCE Technology could offer, helping companies to evaluate the intended experience of their product and the design choices (such as the Manifestations of Meaningfulness) alongside evaluating how it might help with more abstract ambitions such as aiming to be significant, personally valuable, help to identify and reach personal goals, or how it might be art, or create wonder.

8

FINDINGS

8. RESEARCH QUESTIONS: THE FINDINGS

THE MECHANICS OF MEANINGFULNESS AND THE MANIFESTATIONS OF MEANINGFULNESS

8.1 Overview

Meaningfulness, as a concept is not particularly easy to define. However, through the creation of the engagements within the period of this PhD, and the projects within the creative drifting which led here, I present aspects of qualities which suggest a meaningful experience. As explained previously, the concept of designing *for* is vital here, I cannot predict what is meaningful to one person or another, nor can I dictate whether or not they'll have a meaningful life or to which extent. Through observation of how people interacted with past projects, and the engagements described in this PhD, the Mechanics of Meaningfulness and the Manifestations of Meaningfulness emerged.

8.2 RQ1: Mechanics of Meaningfulness

In January of 2018, I published a Medium post as part of my ongoing blog series about my findings in designing for meaningfulness. The Mechanics of Meaningfulness (Carpenter, 2018, January). Here I outlined my thoughts so far about the Mechanics of Meaningfulness - aimed at industry. In this chapter of the dissertation, I outline these through the lens of academia, and relating to Chapter 5.2: Theoretical Drifting.

Throughout the projects I've engaged in and led, I have found particular aspects of projects lacking and some successful. This collection demonstrates both. For example, some projects and devices have led to personal development, while others have been absolutely in-the-moment convenience devices. Some are worthy in their own right such as health care devices which help people live a healthy life. This is not to be downplayed, the importance of these devices is critical to many people's health - but whether it lends towards my framing of meaningfulness is another question. I am most interested in:

Meaningfulness as it facilitates people-to-people connection, people-to-sense of self connection, peple-to-time, and the critical thinking and change which emerges from these.

Therefore, the following collection is representative of these and emerges from my work. In each of the Creative Drifting projects, and each of the engagements, I present how these projects relate to this collection. The below "Mechanics of Meaningfulness" are presented and discussed in this section:

- Personal Development: Identity, purpose, who am I, who have I been, who will I be?
- Moments of significance: Discovery, transformation, the ah-ha moment, leading to identity change.
- Value over function: The result of using a device, as it adds value to your life.
- Meaning in everyday life: Meaningfulness is different to every person in every situation - the ever changing definition of what is meaningful on a daily basis.
- Critical thinking: Asking the hard questions, analyzing and reflecting, leading to growth.

And:

- Offline: Non-connected is the new connected
- Eudaimonia: Human flourishing, seeking fulfillment and purpose.

Personal development

Personal development can be characterized by developing new skills or developing your sense of self (Zimmerman, 2009) and it is both these aspects, and especially the second one which I find lacking in current smart product development today. There are many apps, games, and devices which build motor or cognitive skills. Games such as Guitar Hero (Gaydos, 2010) or Wiimote assisted physiotherapy training (Tang et al., 2014) aid motor skill development and there exist a variety of cognitive training apps with varying degrees of success (Lu, 2018). Developing a motor skill can be considered developing identity since learning a new skill changes who you identify as, for example, identifying as a loop-developing musician as with MusicFabrik. However, devices solely focusing on developing your identity or sense of self are less common. There are plenty of apps for self development (Robbins, 2018) or habit changing (Luther, 2013) but few devices, or smart products facilitate personal self development.

In the general area of smart products, a few examples exist such as ElliQ - the robot / tablet combo proposed by Yves Behar (Wilson, 2017) which uses nudging and a not-too-cute robot companion to convince the elderly to be more active and social. Saleh created a series of bedtime ritual objects - the Future Sleep Kit - to replace smartphone use before bed (Morby, 2017). The Future Sleep Kit features a light which guides people through breathing exercises using aroma and light therapy. Both these examples feature self-development, in ElliQ through the elderly's choice to accept ElliQ as a companion and engage in activities and suggestions from ElliQ to better their lives; and the Future Sleep Kit helps a person examine their current bedtime ritual and create a new one through pre-defined activities which help to alter their physical state to one of being ready to sleep.

A different aspect of personal development is pushing boundaries of identity and causing people to critically self reflect about who they are and how they relate to others. (Carpenter and Overholt, 2017 and Carpenter and Overholt, 2018). This is something I have worked extensively with in Copenhagen Grotesque Burlesque and the experience from that domain has helped me to identify these opportunities with smart products. With Fibo, this was inherent from the start. Our aim was to give partners the opportunity to identify earlier in the child's life as a parent, and truly connect with that new identity. With the Ladies and Men's Room Mixup we aimed to have people question gender and their social norms of using one restroom or another; this could be considered as asking the question "who am I?" in terms of gender. With Future Pleasure Objects, we ask people to consider gender and sex and pleasure and sexuality as four separate issues and relate to what their identity is and how they engage with these. If we are talking about non-binary pleasure objects, then it's a matter of who am I and what do I like or dislike? And far less about *what* I am in terms of gender.

There exists a substantial amount of research about reflection in HCI and it is outside the scope of this PhD to present this here, however I will point to several studies which are relevant for designing for meaningfulness. (This is discussed in more detail in Chapter 5.2: Theoretical Drifting).
Certainly, devices which aim to facilitate self-reflection are facilitating personal development, asking people who they are and why. Mols et al. in their work on everyday reflection (2017, March) do this through the use of devices which *trigger* reflection and this is of particular interest considering the Manifestations of Meaningfulness. Fleck and Fitzpatrick (2010) present a design landscape of reflection and point to how technology's role in designing for reflection is to offer, amongst other things, a different perspective, to produce a record of events for review, and for reorganizing recorded knowledge for a different perspective. These aspects are useful when considering this aspect of personal development. The role of technology, in this case of smart products, is to help *facilitate* this personal development through some form of interaction, whether that be the feeling of Fibo on the skin, the opportunity to express oneself creatively with MusicFabrik, the redefinition of self as a good habit following Diabetic with .TIBA or the exploration of the self with Future Pleasure Objects.

Personal development is a massive topic, and the underlying interest here is in how to develop smart products which aim to help people with their sense of self and their personal narrative (Sas, Wibach and Coman, 2017). Value and culture are intertwined into personal development and models such as Value-oriented and Culturally Informed Approach (VCIA) as proposed by Pereira and Baranauskas (2015) help to identify where people's attention is focused when interacting with technology, in terms of their sense of self. Pereira and Baranauskas explain:

> *"Underlying the VCIA model is an understanding that the design of solutions that make sense to people, meet their demands, respect their values, culture and other social requirements, and, ultimately, does not produce harmful side-effects, requires an understanding of the way different stakeholders value and react to a proposed innovation, seeing the world from their view and cultural particularities."*
> Pereira and Baranauskas (2015)

This is a substantial demand for companies aiming to develop a smart product, or researchers aiming to explore designing for meaningfulness in terms of personal development. As a starting point, companies and researchers can begin by acknowledging that this is a complex issue, and then consider how a device might facilitate someone's personal development in terms of culture, values, social requirements and perspective. Or put simply, how might a smart product enable a person to develop their sense of self?

Moments of significance: Discovery, transformation

The 'ah-ha' moment, the moment of discovery, wherein world views change and new understandings emerge is what I call a moment of significance. Austin explains this as the "first translation moment: creating a new mindset" (Austin, 2013). How to design for an 'ah ha' moment has been explored (for a brief overview, see Farooq, 2005) and is usually in relation to helping designers reach a new mindset. Helping people (users) to reach a new mindset is usually within the realm of designing for reflection, though Löwgren does explore it in his explanation of parafunctionality: as a sudden insight (Löwgren, 2009). This moment of significance might be achieved through self-reflection or attaining one's goals (such as through the use of a fitness tracker). Hallnäs and Redström in describing slow technology, explain how "we should use slowness in learning, understanding and presence to give people time to think and reflect" (Hallnäs and Redström, 2001).

> This time of **becoming**, understanding and coming to a new mindset is what I aim for with moments of significance.

Similar to slow design, designing these moments of significance is not about designing a tool to get to something else, but rather, as Hallnäs and Redström describe, "to amplify the presence of things”, in this case, the thing being the moment of significance.

The walking sticks in the Energy Walk project have aspects of these moments of significance, wherein people walking through the landscape might have an ‘ah-ha’ moment; noticing for the first time the combination of wind, waves and light that contribute to not only the economy but also the mindset and culture of the people in the area. During the creation of this project, researcher Laura Watts, in her work in the Orkney Islands, another energy area, noted that the Orkney Islands are known as the maker islands (referring to the maker movement) as people here simply had to innovate on the spot when something went wrong. There was no backup grid of electricity or someone to come and fix things for you. In this way, the community is very aware in both these areas (Orkney Islands and Hanstholm) about their symbiosis with the nature in the area. Communicating this to visitors by asking them to go for a walk and explore the nature for themselves, to feel the power of the waves and the wind and feel the light on their faces, led to new understandings of, and respect for these remote communities and how they contribute to the world on a greater scale. Though they surely could have read about this on a website, the impact of picking up a hand-carved walking stick and hearing a story told by people involved in the community and walking through the nature, experiencing the fierce winds, had a great impact on those who experienced the project.

Amongst the engagements, Fibo is designed for moments of significance, where the partner gets that ‘wow! / ah-ha / eureka I’m a parent!' moment and as happened in many of the meetings we’ve attended, where some males suddenly realized the impact of carrying another, moving human around in one’s belly, that is not something you can turn off, or swipe away. Ideally, by committing to wearing Fibo and experiencing the movements of the baby, it becomes part of your identity, and you transform into a parent and a partner who (hopefully) connects more deeply and understands more concretely what the mother is going through. .TIBA is also designed for these moments, when a person suddenly sits up and realizes, oh, I’m not hungry, I’m just tired, and this is one of those triggers that I need to be aware of. This is another ‘ah-ha’ moment leading to lifestyle change. With Trækvejret, it might be the moment you are sending an email and suddenly realize you’re holding your breath, (coined *email apnea* by Stone, 2008) and remember to take a few deep breaths during your day, just like you did in the presence of Trækvejret. These moments of significance leading to behaviour change are what I consider meaningful in terms of person to sense-of-self (Trækvejret and Fibo) and person-to-person (Touching Booth, Fibo).

Value over function

There seems to be an increasing focus on convenience in smart products, things to make one's life easier. A prime example of this is Kohler's Konnect system (Kohler, 2018) which demonstrates both aspects of value over function. Somehow, the idea of their devices, such as a tap which pours just the right amount of water "pour 8 ounces of water", or a bathroom mirror which can be asked to be turned on to make up mode, seems smart. But then there's the Alexa-powered toilet which you can ask Alexa (the voice activated home assistant persona) to flush for you, to avoid germs. While the avoidance of germs is a worthy cause, one could use a proximity sensor rather than a voice recognition device which is always listening, even while you're on the toilet. This simple example makes a point for value over function, and as Fritsch, Shklovski, and Douglas-Jones (2018) point out, these IoT devices designed for convenience are pervading our lives.

Nest, the creator of the popular smart learning thermostat (Nest, 2018) introduces their product line as being *right, for the moment*. The thermostat lowers the temperature when one is cooking, raises it (in winter) just before you arrive home from work, lowers it a few degrees as one goes to bed to get a restful sleep, etc. The point is, one never worries about what the temperature is, only if it is right, for this moment. This echoes the work of Kelley and Kelley (2013) explaining how they, and IDEO work, following a right, rapid, rough protocol, making sure the thing is asking the right question, for the right people, for the right context and that it is a rapid prototype (sketch) and that it is unfinished (also following the suggestions of Buxton and sketching (2010)).

> This focus on whether or not the "right thing" is being created is an essential aspect of value over function.

The right thing doesn't have to be the right product, in the case of the Nest thermostat, in the description above, the thermostat never played a part. It was a question of, is it the right temperature? And it wasn't even that question, it was, is it too warm when I'm cooking, is it welcoming to walk in the door after work? Is it comfortable when I go to bed? When the technology disappears to this extent, I believe the value has succeeded over the function.

Fritsch, Shklovski, and Douglas-Jones warn that technology disappearing "becomes something sinister and invasive" (2018). So it is not necessarily the aspect of disappearing which makes the value over function important, it is more along the lines of what Sengers and Gaver (2006) explain, that the challenge of HCI is to balance multiple interpretations in design and evaluation. In the case of the Nest thermostat, the interpretation of whether the effect the thermostat has is valuable depends entirely on who is experiencing it in that moment. Taking the example of cooking dinner, is it the person who is cooking and not feeling overly warm whose interpretation of how valuable the Nest thermostat is, or is it the person who pays the electricity bill and is happy about saving money using the Nest thermostat? Is it the children who are comfortable with the temperature, or is there a member of the family who is fascinated by temperature values and has an idea that 23 degrees for an indoor climate is ideal? And do any of these perspectives have anything to do with the designer who made Nest in the first place?

Senger and Gavers suggest strategies for designing for multiple interpretation such as, amongst others, by unfolding “new opportunities for interpretation over the course of interaction” and by making “space for user re-interpretation by downplaying the system’s authority”. This concept of unfolding new opportunities for interpretation are echoed by Hobye, as he explains the internal complexity of the installations (Hobye, 2015), whereby with more use, more complexity is revealed. This is also what we aimed for with the Electronic Kintsugi, never being explicit in the use case scenario but rather allowing for exploration and for people to create their own value. With Electronic Kintsugi, the function is essentially useless. Focusing on the sound interaction, it makes sounds when touched, but otherwise doesn’t add convenience to one’s life. Instead, it offers experience-created value in that people can derive their own value from interacting with it, or putting it into a context where it creates value for them, as with the design researcher who used it as a medium between him and his (future) father in law.

The Nest learning thermostat takes approximately one week to learn your habits and then begins to offer value via experience. This time delay in value might be one aspect of meaningfulness. As previously introduced in the chapter “Theoretical Drifting: Meaningfulness”, the temporal aspect of meaningfulness is important.

The immediate, hedonic quality is surely valuable for some products, however the longer lasting value gained from the ongoing use of a product is what could lend to a more meaningful life.

The aspect of Trækvejret, that the meaning only emerges when one has learned to take deep breaths throughout their day on their own, or with Fibo, that the partner becomes in tune with the baby’s movements and recognizes themselves as a parent - this is the emergent value that is most relevant when discussing meaningfulness.

Meaning in everyday life

The primary frustration when working with a term such as meaningfulness, is how unstable it is. It changes constantly, from one person to another, from one moment to another. What is meaningful to me, might not be meaningful to you, and what is meaningful now, may not be in a moment's time. So how can we as designers imagine designing for a meaningful experience if it is in constant flux? Perhaps it is exactly the everyday search for fulfilment, meaning, and a meaningful life that is absolutely essential in order to redefine our values in this current time of crisis in the world, as Light, Powell and Shklovski explore in their paper "Design for Existential Crisis in the Anthropocene Age" (2017). This is a point I return to in Chapter 10: Discussion.

Mols, van den Hoven and Eggen present a series of artifacts for everyday reflection including "Cogito", a small pyramid which unfolds to trigger reflection (2017, March). They explain: "Short text messages can be sent throughout the day during brief moments of realization, experienced emotions or short breaks. These are mainly intended as notes for future elaborations, rather than expressive reflection in themselves". In this example, it's up to the user to recognize a moment of significance and store a message for future reflection.

This speaks to the everyday nature of our changing perspective of what might be meaningful. By recognizing when one is experiencing something meaningful, or which might enable future meaningfulness, we begin to understand ourselves better, and plan for our future selves. Hallnås and Redström explain that "When we let things into our lifeworld and they receive a place in our life, they become meaningful to us." (2002) But, as explored in Chapter 5.2: Theoretical Drifting: Everyday Objects, the designer must realize that their designs will be interpreted in a variety of ways and perhaps not as they originally intended (Senger and Gaver, 2006) and it is this explorative action that constitutes a search for meaningfulness in everyday life.

MusicFabrik demonstrated this quality by offering an opportunity to spontaneously pick up and play the speaker, creating music. This addresses the everyday, in that it can happen at any time and doesn't require special circumstances such as putting aside time for reflection, meditation, or life planning, but rather is a way to express oneself and develop one's identity as a musician and as a creative person. With the Future Pleasure Objects, people can explore their bodies and their attitudes towards pleasure. Perhaps there is some ritual involved here or perhaps it is as simple as sinking into a massage chair and connecting to one's body. It is the decision to engage in an activity, and then develop the training of the self to critically reflect and *act*, learning new behaviours or changing old ones. Ghajargar and Stolterman propose 'smart objects to think with' (2018) highlighting that "it becomes hard to separate the object to think with from the person who has a reflective relationship with the object." Here they are discussing smart objects which "make me think". This making-me-think way of reflecting is mirrored in much of HCI's reflection research but, as above, the difference is in the action emerging from this 'make-me-think' activity. It is this action which differentiates designing for everyday meaningfulness from designing for everyday reflection.

Critical thinking

While many of the "mechanics" have been directed at what the experience should be, or how the product behaves or what it enables, this particular mechanic addresses specifically critical thinking on behalf of the product developers and design practitioners. Critical thinking on behalf of the end user is at least implicit, if not explicit in the other "mechanics" as they have been presented in relation to reflection and action. As this PhD is done within the context of industry, many of the activities engaged in have included meetings, seminars and presentations with companies designing smart products. As such, it is important to consider how companies, designers, researchers and others working with smart products critically think about what it is they are making.

Companies may be developing a new product for any number of reasons, being first to market, improving incrementally on existing designs, changing domains (for example from health to fitness). An important question to ask when developing a new product is "why?". This might seem like Design Thinking 101 but many companies I have encountered are not always prepared to answer that question in terms of more than the surface answer such as: "because it works as a heart rate monitor medically and it would perform well as a sport and fitness accessory". As researchers exploring the role of smart products, I aim to dig deeper and hope to answer the question of "why?". Why is this product necessary? Why would someone want it, or *need* it in their life? An extended example from industry is provided below to provide context to this point:

> One example of a consumer facing product which demonstrates both an important and useful IoT function (safety) and yet is also inherently unnecessary from a functional point of view: Juicero, the smart juice maker that caused a stir in the IoT world in 2017 due to its high production and purchase cost and lack of adequate need for connectivity (and which was discontinued as a product in 2018). "The device Evans spent three years laboring to invent is a $400 WiFi-enabled tabletop machine that squeezes juice … out of a bag of Juicero-brand juice" (Burneko, 2017) Burneko refers mainly to the primary function of the machine,

squeezing juice out of bags, however the machine does do more, for example, it won't squeeze the juice if there's a recall on produce due to contamination. As Juicero CEO Jeff Dunn explains, they use the "connected data so we can manage a very tight supply chain, because our product is live, raw produce, and has a limited lifespan of about 8 days" (Dunn, 2017).

A conflict emerges. One could, as Burneko alludes to, simply receive bags and squeeze the juice out of them or have juice boxes delivered to our doors via a subscription service. But, this doesn't solve the contaminated juice problem. Does this justify a $400 purchase (earlier in 2017, it was $700) and a $120 million dollar investment? (Shontell, 2015). Maybe, since it might solve the problem of contaminated consumables and it certainly is an early implementation of how the future might look where our consumables are monitored in the home, as we are about to consume them. (This could also be done with a barcode and a phone camera with a scanning app). It's an example of how a connected device can be useful (safety and recall) and yet al.so overambitious and possibly unnecessary (luxury bag squeezing machine). Furthermore, it served as a testing ground for safety recall (interesting to companies and organizations hit by the financial and branding impact of recalls) but not necessarily to end-consumers who have to deal with a large, expensive and ultimately unnecessary device on their countertop.

Does Juicero, which could easily have been a non-connected product (juice bags) really need to be connected, and if so, who did it really serve? It's important for researchers to look to what is emerging on the market; to need to look further than our peers and examine what's happening on the market now and how our work, our research, can impact that, both now and in the future.

Analysis and criticism are key aspects of critical thinking, and academia is good at this. I suggest that improvements could be made in combining the academic ability to do critical thinking, analysis and criticism with industry and product development.

Fritsch, Shklovski, and Douglas-Jones (2018) present an overview of IoT Manifestos, essentially, criticisms of smart products put forth predominantly by design focused practitioners asking us to question what it is we are bringing into the world. They highlight concerns around privacy and responsibility and suggest that we "re-engage skepticism and to take the time to think more deeply". The scope of this dissertation does not include privacy, however the overarching need to think critically about which devices we are creating is multi-faceted and *why* we are creating something is a significant part of the data, privacy, ethics and sustainability concerns which Fritsch, Shklovski, and Douglas-Jones present from the various IoT Manifestos. This "thinking more deeply" can be extended to many stakeholders in the process of product development.

At an event for Hackaday (a community of hackers) I presented designing for meaningfulness which was a slightly different topic to the rest of the day's program which mainly focused on use cases with electronics hacking. Many of the attendees who are hardware developers in companies, came up to me after the talk to discuss designing for meaningfulness, explaining how it was an important talk for them to hear to be motivated to consider their role in making products that might be important, and meaningful and those which are more novel, or gadget-like in nature.

Within HCI, there is ongoing criticism of the field, and its future (for example, Beck and Stolterman, 2017) and it is in this vein of critical analysis that I suggest product developers have a similar practice of asking the big questions about their products. Much of this can be determined by a framework or handbook, for example, the Human Centred Design Toolkit by IDEO (IDEO, 2018) which I have encouraged many companies to review, but as researchers, we might ask how we can provoke or enable companies to ask themselves these questions - beyond just the user scenarios but whether or not one should even make this product at all, who it really serves (Juicero primarily served major beverage industries in terms of supply chain) and why this product is necessary, being honest about the answer. This of course is complicated, given a focus on profits and loss, and company growth, but it is important to consider.

I feel this approach is in line with Bardzell, Bardzell and Stolterman (2014), where they propose analysing the critical aspects of a design and ask about a variety of parameters. For the sake of this chapter, I highlight the parameters of: The topic/problem space (the domain); The purpose of the design; and The functionality (discrete capabilities). While Bardzell, Bardzell and Stolterman are interested in critiquing critical design, their proposed parameters function well for asking these initial questions of a product as it is being ideated, or even as it is successful in one domain and is being transferred to another.

Offline: Non-connected is the new connected, a possible future Mechanic of Meaningfulness?

While it may seem counterintuitive to both be working for a technology development company (FORCE Technology) and suggest we focus on non-connected as a quality, it is a factor which has become prominent throughout this dissertation. In IdemoLab, we have "Rule zero" which is "No technology for technology's sake" and we use this rule in discussing initial ideas with customers. This resonates with the Mechanic of critical thinking as we often ask "Why?" when encountering new ideas. The first step in our 8 Step Service is to analyze where this idea came from and where the need for it actually arises. Although I have not included 'offline' throughout this dissertation so far, it has arisen as a common theme and therefore I introduce it now as a potential Mechanic of Meaningfulness, and reflect on how it has arisen throughout the engagements.

When designing the Trækvejret sketch, I questioned just how much technology was needed to have an effect. It was in some ways, an exercise in simplicity. What would be the minimum viable technology that could help people to take a breath? There was no reason for it to be connected, any kind of internet connectivity was pointless, the entire concept revolved around people analyzing themselves based on their own sense of body and not on quantified data. As previously given as an example in the Trækvejret engagement (chapter 5.3), Hartzog and Selinger explain,

"A chip-centric mentality has taken over, one that is guided by an overly simplistic principle: 'Internet connectivity makes good objects great"

(Hartzog and Selinger, 2016).

This is echoed by Cila et al. (2017) who give an example of: "...the blog "we put a chip on it" (http://weputachipinit.tumblr.com/). Its tagline "It was just a dumb thing. Then we put a chip in it. Now it's a smart thing" accurately summarizes the current approach towards smart products. Clothespins that notify you when the laundry is dry or socks that keep track of how many times they were washed indicate how shortsightedly IoT could be executed."

It is this short sighted approach to IoT which provoked me to start investigating just how much non-connected devices could offer in an era of IoT hype. The need to disconnect is becoming a dominant theme in mainstream culture with digital detox guides (Weir, 2017) and offline holidays becoming more popular (Conghaile, 2017). Pierce in his speculative design piece about a Wireless Derouter (2016) introduces many examples of the critique of the always-on society, and points to emerging themes such as "sanctioned areas of disconnected space", "disconnective counter products" or "wireless nonspots", all encouraging offline, non-connectedness. In line with this is the example of https://chris.bolin.co/offline/ - a website only accessible when one is offline. There is also considerable critique of IoT and ethics of the IoT in terms of privacy and data generation (Gorm and Shklovski, 2016) and usage (Sheth, 2016).

However the point is not just to be offline, or disconnected, it is also to be unquantified. With Trækvejret, one should measure for themselves their perception of their breath, and then repeat that, on their own. With Fibo, there is no feedback about how many times the baby is kicking, even though this is something that parents wanted (especially in the USA where number of kicks should be registered by the mother) because this would be done by the patch the mother wears, not by the wearable bracelet, Fibo. This bracelet was about unquantified data, namely, about translating and sharing physical experiences. Fibo is connected, it must be connected to transmit data from the mother's patch to the partner's wearable bracelet; that represents half the issue. It might not be offline, but it isn't connected in the sense of reporting, quantified self or notifications. It offers a visceral experience instead. I discuss "the current day novelty and importance of an app-less device" in Carpenter and Overholt (2018).

Likewise, MusicFabrik and Electronic Kintsugi were not connected, they had no need to be; they offered an interactive experience and had no need to be online to offer these experiences. Perhaps in future renditions, it could be beneficial for the musician to upload their music somewhere and then there should be some kind of connectivity option. With Electronic Kintsugi, some of the concepts generated by workshop participants in the first workshop had connectivity in mind, such as one concept of an Electronic Kintsugi bowl, that when stroked, would send a physical postcard to the person's grandmother. In the second workshop with the design researchers, the concepts were more offline-oriented such as the musical cereal eating experience, or the language-replacement mediator between an English speaking person and a Danish speaking person. In another case, Future Pleasure Objects can be connected devices, but perhaps, ideally, are not - for privacy reasons. Wynn et al. (2017) highlight the concerns of connected personal sexual devices, not least of which include broadcasting personal usage data, and moving on to putting people in dangerous situations by disclosing their sexual partner preferences.

In HCI, non-connected is nothing new, long before IoT became an everyday term, and still afterwards, there exist hundreds of non-connected concepts and prototypes presented at conferences, noteably at TEI (Tangible, Embedded, Embodied Interaction). It is the new on-market products which I address in this chapter, and researchers and designers working on these products might ask:

> Is there an actual need for connectivity, or quantification, or generation of data in a given product? Or might it be designed as a non-connected device?

Summary and introduction of Eudaimonia as an additional, or overall mechanic of meaningfulness

The Mechanics of Meaningfulness emerged from reviewed literature, the research through design method of exploring the insights gained from the engagements created, and from collaborations with companies including discussions, interviews and workshops.

The Mechanics of Meaningfulness are not a final list, instead, they are a suggestion for future researchers and those engaging with industry to create new smart products.

Adding to this list is eudaimonia, designing for human flourishing and purpose. This aspect has been explored in the Theoretical Drifting chapter (4.2), and considering the aspects already presented, it fits in as an overall theme, relating to each one and contributing to meaningfulness in the end. Considering each mechanic in relation to eudaimonia:

PERSONAL DEVELOPMENT
Huta and Ryan describe eudaimonia as "seeking to use and develop the best in oneself, in line with one's deeper principles" (2010) which fits well with personal development, aiming to develop who you are (identity, principles) and utilize those aspects of yourself.

MOMENTS OF SIGNIFICANCE
Defining moments of significance by whether they match one's ideal for themselves in terms of how they flourish, is this a moment of significance in terms of my greater concept of myself, and who I want to develop into?

VALUE OVER FUNCTION
Value can be as personal as 'meaningful', and what is valuable to one might be defined by their sense of self and what is most important to them in line with their principles. Therefore, for value over function, the value is derived from the person's sense of eudaimonic direction.

MEANING IN EVERYDAY LIFE
Light, Powell and Shklovski explain, "going towards the future with grace and bravery is simply better than travelling with fear, small-mindedness and hate. It makes for a better- fulfilled life." in their exploration of a eudaimonic future in light of the existential crisis we face in the world today. (2010). Therefore, we can approach each day with "grace and bravery", designing for that as we aim to help people discover their own abilities and definitions of a fulfilled life.

CRITICAL THINKING
Again, this is an aspect which will be revisited in the discussion and conclusion of this dissertation, as I believe that Light, Powell and Shklovski have an excellent point, where they argue that currently, technology is more about enhancement, and less about eudaimonia, or the good life (2017).

They highlight:

> *"Throughout this realignment towards greater agility, we can design for creative thinking, not just in the present, but in how we greet futures, so we meet change with a flexible responsive approach, ready to make the best of it, mitigate the worst of it and find fulfillment in the work we have to do and choices to be made."*
> (Light, Powell and Shklovski, 2017)

This is a potential outcome of encouraging critical thinking as a mechanic of meaningfulness in smart products, not just asking why, but also asking about the future.

NON-CONNECTED

As eudaimonia is concerned with betterment of the self, one might relate this to something such as quantified physical self, and connected fitness devices. However, in terms of fulfilment, life purpose and principles, connected devices aren't the important factor. A connected self is. A person who is connected to their own principles, who recognizes what they need to do to be fulfilled and to then connect to others and be of service to them in helping them fulfil their life purpose and connecting on a person-to-person level. This goes beyond communication apps or technologies and focuses on the core of being a person amongst other people in this world. An IoT device is not necessarily going to solve that for anyone but perhaps considering how to create more non-connected experiences might be one way forward.

These Mechanics of Meaningfulness, as a starting point, offer a way of thinking about the development of smart products as expanding past the technologies required, the user interaction scenarios imagined, and the business models proposed. These are meant to facilitate discussion and debate, to ask some tough questions about why we are making the products we are making and how we might help people who use these smart product to explore the quality of meaningfulness in their lives, rather than just focusing on convenience as so many current smart products do.

8.3 RQ2: The Manifestations of Meaningfulness

Throughout this dissertation I have described the physical characteristics of the various creative drifting projects and the engagements developed during this research period. The creative drifting projects from illutron, GeekPhysical and IdemoLab were projects where I can point to what we did and elaborate on the physical characteristics, or Manifestations of Meaningfulness as I call them. The engagements made during this PhD are examples of experimenting and gaining insights.

Before describing these characteristics I present a brief review of the Manifestations of

Meaningfulness of the projects and engagements presented thus far:

illutron

LADIES & MEN'S ROOM MIXUP
Doors with LED Matrixes - essentially non screen but iconic and action generating.

EXPLOSION VILLAGE
Drums with lights and sound resulting in a fire explosion. Non screen, tangible, primal.

N7331227
Surprising interaction, awareness of self and movements. Non-screen.

GeekPhysical

CRITICAL CORSET
Tightening corset - bodily awareness, non-screen, an intensely felt experience, invisible to others.

ENERGY WALK
Hand carved walking sticks with a smooth ball of wood on the top containing an audio player reacting to location tags with headphones. Craft-based, everyday object which offers a tangible, non-screen experience.

THE TOUCHING BOOTH
Two chairs with a circuit that results in a photo. Touch, tangible, non-screen but resulting in a visual output.

IdemoLab

HOME PILL DISPENSER
Non-screen display with shine-through icons, still visual but requires tangible interaction to activate.

THE TOUCH LAMP
Non-screen, tangible (touch based interaction), everyday lamp used for a variety of contexts, value over function.

DIABETES PEN CAP
Large e-ink screen for easier readability, "no new buttons, no extra work"; just press the pen down. Tangible, everyday object.

Engagements

FIBO
Non-pregnant partners feel the movement of the baby. Tangible, jewellery-design (crafted), non-screen.

ELECTRONIC KINTSUGI
Everyday object (bowl) which has no defined purpose, based on traditional Japanese craft, non-screen.

TRÆKVEJRET
Non-screen, tangible in the sense of presence, it is there, it moves in a fluid way reminiscent of the body's breathing movement.

MUSCLE MINDER
A felt experience, connecting mind to body, tangibly feeling the tightening of the string around the muscle before doing a repetition.

MUSICFABRIK
Tangible expression of craft - music making on an "everyday" object - the now-common portable Bluetooth speaker. Non-screen.

.TIBA
Non-screen experience of inputting when a habit is occurring and the intensity of that feeling. Connecting to the feeling, mind-body connection.

FUTURE PLEASURE OBJECTS
A variety of objects whose purpose is to explore pleasure and the body in a non-screen, tangible way. Employing craft through for example, Ardourino, wherein a ceramics artist and a biohacker combined forces to create the gel applicator and the gel.

Four primary Manifestations of Meaningfulness have emerged throughout working with the engagements and reflecting on the creative drifting projects:

1. Non-Screen
2. Tangible
3. Craft
4. Everyday Object

These can be extended indefinitely to include more Manifestations of Meaningfulness or to re-evaluate the particularities of one of the terms. Non-screen might mean non-visual or it might mean strictly, no screen present. Tangible might be something one manipulates with their body, or something which is facilitating bodily engagement. An everyday object might come from traditional craft but a crafted object might not be an everyday object. For the sake of this dissertation, the scope is limited to these four, as they have come to represent some of the characteristics leading towards artefacts which enable meaningful experiences.
Ghajargar and Stolterman describe how the “sensory and physical characteristics of the artifact itself play crucial roles” in IoT devices, and describe how “tools for reflection need to create thoughtful interactions with the user, instead of merely displaying information.” (2018). It is with this lens that I elaborate the Manifestations of Meaningfulness which I define as contributing to designing for meaningfulness.

For each of the projects and engagements, related works have been explored in the associated publications. Therefore, what follows is a brief description of each Mechanic of Meaningfulness.

Non-screen
Non-screen refers to not having a screen such as a mobile device, computer, or interactive screen (tablet, etc) present and required for interaction. While some artefacts might eventually use a screen such as the Touching Booth, or .TIBA which sends text messages of motivation; the interaction with the artefact is not screen based.

While significant research exists on how screens affect people physically (Sigman, 2012), socially or mentally (Lanette and Mazmanian 2018), my focus is more on what designing for other-than-a-screen can enable. This relates back to tangible computing, imagining how to interact with the world around us and the objects we use, and not necessarily doing everything through a representation of a desktop. As was explored in the "physical computing" section, we have many more senses than just sight and however much we rely on sight for so many things, these examples of projects and engagements demonstrate that our other senses can also be engaged to offer a richer experience.

Other recent projects in HCI employ non-screen interactions such as the Calm Station (Kim, Park, and Hong, 2017), a wooden tray on which a metal ball rolls around, notifying users of incoming alerts such as texts or calls. Calm Station is described as having "abstract, poetic movements" and is an example of low-attention ambient notification. One notable feature is that it does not demand attention, it is a *low-attention* device. Even though it notifies someone of the opportunity to check a screen, in itself it is not a screen, and people can choose to go to their mobile device or not. They don't need to check a screen to find out if they need to engage with their mobile device.

There exist several interesting on-market products[1] which utilize a non-screen approach:

- Dodow, a sleep aid which uses light to aid synchronization of breath, leading to sleep.
- Nokia Steel, a step tracking watch whose watch screen has three hands, two for hours and minutes and a smaller area for percentage of steps taken out of one's daily step goal. It does have an app, but essentially, one does not need to use the app to benefit from the data provided on the watchface itself.
- Moodo, a 'surround sound' approach to scent, providing a scent landscape for the home.

Dodow utilizes light to guide meditation, Nokia Steel uses a second watch hand to convey information and Moodo uses scent as an output. These are three simple examples however they show how smart products can be beneficial to people without utilizing screens. Nokia Steel and Moodo do require apps, and while Nokia Steel can function entirely without the app after setup, Moodo is controlled via an app.

I understand that screens or interfaces are still necessary, and I don't insist that we should abolish screens. I instead emphasize that there are other ways of interfacing with the world or receiving information. As researchers, we can work with companies who might not be familiar with the multitude of sensors, actuators and introduce them to these possibilities. I'm not necessarily anti-screen so much as I am interested in embodied interaction, person-to-person or person-to-sense of self connection, and the possibilities inherent in looking past the limitations of the screen.

1 ***Dodow:*** *https://mydodow.com/dodow/en-us/home* ***Nokia:*** *https://health.nokia.com/es/en/steel* ***Moodo:*** *https://moodo.co/*

As I have presented for each of the projects and engagements which use a non-screen approach, the engagement is more focused on a bodily experience leading to other qualities. Fibo is a tangible experience, leading to reflection about relationships and roles. Electronic Kintsugi allows for creative expression and exploration, becoming a device of requirement, being useful in different ways in different contexts. Trækvejret encourages breathing through movement. Muscle Minder makes the user focus on their muscle via actually squeezing that muscle with a band. A non-screen approach opens for possibilities with other types of sensors and actuators, and experiences.

Höök et al. describe how technologies form our experiences:

> *"These technologies will (depending on how we design them) encourage certain movements, certain aesthetic experiences, certain practices and understandings of our bodies—while not encouraging others. They will influence our availability for certain qualities of interaction and not others. They will alter how we move, our postures, our muscles and nervous system reactions and orientations. This will continue to affect how we do our work tasks as well as our leisure activities, social communication, play, and artistic expressions, and therefore ultimately, how we live. This is why we need to cultivate our understanding of what it means to be a sensing, feeling and moving body, living in the world, shaping and being shaped by our lifeworld."*
> (Höök et al., 2018)

A meaningful experience may derive from a non-screen approach. As people focus less on their screens, and more on their bodily engagement, themselves, and each other, there is a potential for meaningfulness to occur. This does not mean it cannot occur with a screen-based approach, this is simply one potential physical characteristic of consumer facing smart products which enable meaningful experiences.

Tangible

There are many facets of tangibility which are not within the scope of this dissertation to describe, so to correctly frame what I mean by tangible, I refer to Chapter 5.2: Theoretical Drifting, wherein "tangible" refers back to physical computing and can be something which incorporates the body, is felt, or is physical in the nature of its interaction.

In their work on tangible cognition, van Gennip et al. (2016) revisit the history of tangibility in HCI, noting "Despite this academic attention, most of the interfaces we touch in daily life and do research on in HCI are of a less tactile nature, typically opting for the flexibility of on-screen interactions and various GUIs" and introduce embedded cognition: "the notion that cognition happens not just within the limits of our mind/

brain but is readily supported and replaced by elements around us" and that these elements around us are ones which we navigate "seamlessly" (Gennip et al., 2016). Allen also refers to embodiment with regards to knowledge creation stating, "Touch would also seem to lead to more intimate experiences, and more sensuous, embodied relations to knowledge." (Allen, 2015). It is this embedded cognition, through interacting tangibly with artifacts that I focus on.

This could be for example, the visual interaction of watching the physical motion of Trækvejret; the feeling of stroking the Electronic Kintsugi bowl and experimenting with different types of touch; the pressing and tapping of Fibo as the baby kicks and moves; the pressure felt as Muscle Minder helps you prepare for exercise; or the feeling of turning .TIBA to acknowledge the intensity of a habit. Tangibility here could lead to meaningfulness through physical interaction with the device, the body, the self and the cognitive activities which take place during this interaction. For Fibo, it's realizing that it is *your* baby moving, or for MusicFabrik, not only pressing buttons and getting sound, but composing a piece of music.

A few examples of on-market tangible devices include[2]:

- Moment, a non-screen, haptic based watch for notifications which come in the form of tactile illusions.
- Calming Stone, a device to help with anxiety. It is held in the hands and records heart rate, pulsing in rhythm with your heart rate (both physically pulsating and via light) to help calm you down.
- HEY Bracelet, two devices worn by a couple, and when one is thinking of the other, the bracelet sends a squeeze.

All of them act on or with the body. On HEY's website, the description is: "It's the first wearable that mimics a real human touch. Not with a mechanical vibration or buzzing sensation, but an actual gentle squeeze. HEY will forever change the way people stay in contact. The stylish wearable makes technology meaningful and is a welcome addition to 'old fashioned' text and video communication." This addresses several aspects: firstly the lack of vibration or buzz, as earlier discussed with the Fibo sketch, we wanted to avoid a buzz because, as one parent put it, "babies don't buzz". Taking the 'buzz' problem further, in Muscle Minder, we wondered if people have become too used to a vibration notification, as vibrations are used for many apps and devices such as fitness trackers or smart watches. (Research in haptics points to the complexity and breadth of haptic sensations and semantics as can be read in Seifi and MacLean, 2017). Finally, although HEY doesn't describe their definition

2 ***Moment:*** *https://wearmoment.com/* ***Calming Stone:*** *https://www.kickstarter.com/projects/calmingstone/calmingstone-the-ultimate-calming-experience?token=77994e32* ***Hey:*** *https://www.heybracelet.com/*

of 'meaningful' they do point to meaningful as an aspirational quality for technology.
Tangibility as a physical characteristic provides for embodied cognition (Lindgaard and Wesselius, 2017), interaction with the world around us, including everyday objects, ourselves and others and ties into the characteristic of non-screen. Tangibility could therefore be a physical characteristic for artefacts which are designed for meaningfulness.

Craft

By craft I refer to the production of individually made products, preferably by crafts people using traditional craft techniques. The aspect of craft, or an individual product and the preciousness that comes with that, is something that Tsaknaki described extensively in her dissertation (Tsaknaki, 2017). She explains how society is increasingly appreciating craft again, and that interaction design can benefit from working with traditional craft to explore values of preciousness, both in terms of materials used and in terms of emerging values from the piece being created.

Similarly, Padfield et al. (2018) explore the aspect of craft in relation to early prototyping within the Maker culture, describing the quality of individual crafted and therefore unique pieces as being important to move away from "uniform aesthetics and material limitations" (Padfield et al., 2018).

Websites such as Etsy https://www.etsy.com/ or Amazon Handmade (http://www.amazon.com/Handmade/) demonstrate a demand for such items - Amazon Handmade opened in 2015 as a competitor to Etsy.

Tsaknaki (2017) explains "an artefact made by a single craftsperson in a studio is embedded with a different set of values, compared to one made through industrial production processes" and addresses the problem of planned obsolescence. Craft comes more into focus as people turn to places like Etsy or Amazon Handmade for gifts or items for themselves, and as people (hopefully) become more aware of the sometimes unethical and non sustainable practices of mass production.

Fibo was part of a craft based program, teaching traditional methods of jewellery design, and was developed by three people, working on the 3D model, material choices, casting of metal, and final assembly.

With Electronic Kintsugi, we worked with the Kintsugi artist, together experimenting to find out which qualities of touch would be interesting from the perspective of the carefully laid Kintsugi traces. We imagine a future prototype where we work with the Kintsugi artist to create traces of a higher conductive capability to allow for an enhanced experience. Even Trækvejret, just being laser cut, attracted a sort of attention where people asked if we had made it and were intrigued by the material, the etching and kerf-bent wood as they hadn't experienced anything like it before.

Not necessarily on-market but imagined for market, the following devices demonstrate craft in their production[3]:

- Google Moodstone: a device to keep a diary of times of anxiety or calm. A small, stone shaped object crafted from Japanese cherry maple wood, which has raised bars. Stroking the bars one direction is rough and indicates anxiety and stroking them the other direction gives a smooth sensation, indicating calm.
- The Meditation Egg (Edwards et al., 2017) is a wooden egg shaped object which when held, plays an audio meditation. "Critically wood is a poor conductor of electricity and focus is needed to hold the object so that a capacitive connection can be made with the metal contacts inside.".
- 8 Bitskleed by Dorith Sjardijn is an art piece, weaving "electroluminescent material into an existing carpet and backed the entire rug with rubber for durability.".

These three examples, not on market, but based in craft, demonstrate how crafted artefacts can potentially present more value than their mass produced counterparts.

The Google Moodstone, which I've written about extensively in my blog[4] represents an aspect of craft and tradition, and as I explain in my blog post:

> *"It is made of wood, in fact, "hand-carved from a small block of Japanese cherry wood". There's something about this quality, it's hand-made (we'll get into that in a second). It comes from something precious—Japanese cherry wood. It's not disposable in the same way as a silicon encased object. It doesn't feel medical or fitness like. It is something of quality, of an old-world sense that this is something valuable. You want to feel the smoothness of the wood, the affordance is stroking: smooth wood combined with raised bars, it's fairly obvious what you should do with it. This was a design decision by AQWorks who explain: "Brushing a thumb left-to-right across the protrusions feels pleasantly smooth and records as a positive emotion. Brushing right-to-left and the protrusions dig slightly against the skin in resistance, recording a negative emotion.""*
> (Carpenter, 2018, June)

The Meditation Egg is wooden, and as the creators describe on their

3 **Moodstone:** *http://www.aqworks.com/en/work/moodstone/* **Meditation Egg**: *http://www.lizedwards.net/wordpress/?p=194* **8BitsKleed:** *https://weareoca.com/subject/textiles/looking-future-textiles-science-technology/*

4 *https://medium.com/@VanessaJuliaCarpenter/meaningful-devices-394c5cdab65c*

site[5], “The egg is made from wood because of its sensory qualities; the way it warms in the hand, its smell, texture and weight, and (if partly seasoned), the way it ‘lives’ and changes over time.”

The 8 Bitskleed carpet is hand-woven, and represents the craft present in the world of smart textiles, where craft exists as a primary stance, with technology coming second. Valentine et al. elaborate: “Within this work, the ‘smartness’ of technical novelty is replaced with a concern for the intellectual and creative potential of interweaving new concepts, materials and technologies”. (Valentine et al., 2017).

The preciousness which Tsaknaki describes is the essential element of craft when considering designing for meaningfulness. Tsaknaki describes preciousness in terms of the materials, how the materials are used, and “the value and significance a computational artefact might have for a user” (Tsaknaki, p. 119, 2017).

This relates back to the Mechanics of Meaningfulness and the aspect of “moments of significance” and “value over function”. Within craft, the value seems to be, in these examples, much higher than the function; and the significance is the primary concern. The combination of significance alongside preciousness, alongside the slow and imperfect production make craft an interesting element of designing for meaningfulness - not an essential element, yet one which offers qualities which are not typically found in today’s silicon and aluminum encased smart product offerings.

Everyday objects

The concept of everyday objects as things we relate to, to construct our reality and to relate to our world was covered in Chapter 5.2: Theoretical Drifting, so here, I focus on how the other three Manifestations of Meaningfulness play into this one. An everyday object is a physical object, it has presence: it is in the world. In some ways, this is the tangible characteristic, it is something you can hold, touch, engage with in a physical sense. Most everyday objects, so far, do not have screens, except those screens which are in themselves, everyday objects such as a television or computer screen. The elusive smart fridge has yet to become ubiquitous as we’ve been promised so many times, despite even recent attempts from companies such as Samsung (Samsung, 2018).

Finally, everyday objects often originate in craft, especially in Denmark, where there exists a strong tradition of “Danish Design” featuring natural elements and textiles, providing a sense of handmade, high quality material and craftsmanship.

Craft is also present in the things we treasure in the home, a vintage telephone which has been assembled by hand, and has carefully routed edges, or the table I’m typing

5 *http://www.lizedwards.net/wordpress/?p=194*

at now, a large, oak table with many knots in the wood and rough edges, giving it an unfinished quality but clearly showing how someone has taken the time to sand and oil it thoroughly.

Everyday objects offer a portal to designing for meaningfulness in that these objects constitute our understanding of the world (Wakkary, 2017), they represent our identity, they hold memories and emotions (Ahde-Deal, 2013) which we're not necessarily even aware of until we sit down and think about it.

By designing an artefact which is an everyday object, people can use it to express themselves and to connect to others. I discuss this extensively in my Master's project, (Carpenter, 2009) where at a mobile device UI/UX company we used everyday objects around the office to act as ways of describing new features of mobile applications. Similarly, Nicolette Bowdewes created the Tools for Therapy (Bowdewes, 2018) a set of familiar objects, where Bowdewes describes them as "referring to various psychological themes and archetypes. A soft round leather ball could stand for loving or smothering care, a rubber string for flexibility or even sneakiness." (Bowdewes, 2018).

Two products which are on-market or nearly on-market and incorporate everyday objects include:

- Yibu by Frog Design[6] - a set of wooden shapes described as "five crafted wooden toys embedded with sensing technology, which are connected to a character experiencing environmental challenges on the screen. Children who play the game learn about the world around them and feel empowered to positively influence it." so while it has a screen element to it, (again, I'm not anti-screen) it does focus on tangible embodied interaction, personal development, value over function, and meaning in everyday life.
- Storyball - a ball for children to play with which is specifically marketed as a "screen-free" interactive experience. The ball engages children through role playing and story telling, where the children play active roles with the ball.

These two examples demonstrate how everyday objects can be immersive, and how they translate the Mechanics of Meaningfulness (as with Yibu) and the Manifestations of Meaningfulness (as with Storyball).

Everyday objects in themselves might not lead towards meaningful experiences, but once enchanted (Rose, 2014) with technology in a way that makes sense to engage with, they become interactive devices which can perhaps lead towards meaningful experiences.

6 **Yibu**: *https://www.frogdesign.com/work/yibu.html?utm_campaign=Yibu2016*
StoryBall *https://www.kickstarter.com/projects/848480002/storyball-the-screen-free-smart-toy-that-keeps-kid?ref=project_tweet*

To summarize, the Manifestations of Meaningfulness which I've defined so far as contributing to designing for meaningfulness include: non-screen, tangible, craft and everyday objects.

By drawing our attention to the real, physical world and to those we interact with, and the objects that surround us, there is a experiential quality of embodiment, appreciation of detail, and perception which these qualities offer.

As significant research is being done in areas of mobile interaction, augmented reality and virtual reality, the shift to ask companies and researchers how they might design non-screen, tangible, craft based everyday objects encourages us to revisit these qualities and perhaps consider how they might contribute to the Mechanics of Meaningfulness, and ultimately, designing for meaningfulness in smart products.

9

TAKEAWAYS

9. THE THREE TAKEAWAYS

Throughout this dissertation, a path has been followed, leading from the creative drifting projects of illutron, GeekPhysical and IdemoLab; the theoretical drifting towards meaningfulness; the explorations of meaningfulness with companies and the Mechanics of Meaningfulness and the Manifestations of Meaningfulness.

This path has been in line with the method of programmatic research through design. From the program are extracted takeaways, lessons learned or qualities found. The three takeaways are qualities of designing for meaningfulness. I return to Jung et al. who were previously introduced as explaining:

> "The meaning of an object can only be ascertained by linking it with something of value, and something of value can gain meaning by being linked to something else of value. What really makes the difference is the nature of the linkage."

(Jung et al., 2011)

To me, these links are one way people may find meaningfulness in their experiences. I interpret this quote as how interacting with an object and forming some experience which elicits some value can then be ascribed to an overall life purpose. I therefore present three such links, which represent the overall quality of meaningfulness which I see as emerging from this research. There are likely many interpretations of what designing for meaningfulness might entail, and the types of links which could enable a meaningful experience. Within this dissertation, I have presented five 'Mechanics of Meaningfulness' which are essentially, five types of links, and the Manifestations of Meaningfulness might be considered as four other types of links. I believe these can be best grouped into the following 'links':

1. Enabling people-to-people links to foster, maintain, or strengthen a human connections;
2. Enabling people-to-sense of self links to tell or enable stories and thus, help to build identity; and
3. Enabling people-to-time links to allow for reflection of past, present and future self, and the making of meaning.

These links have been presented in the publication "Designing for interpersonal connections in future technologies: An annotated portfolio of jewellery devices". Proceedings of the 2018 NordDesign conference, Design Society" (Carpenter and Overholt, 2018). In this chapter, I present these three takeaways in the form of annotated portfolios (Figure 20) which I explain on the following page.

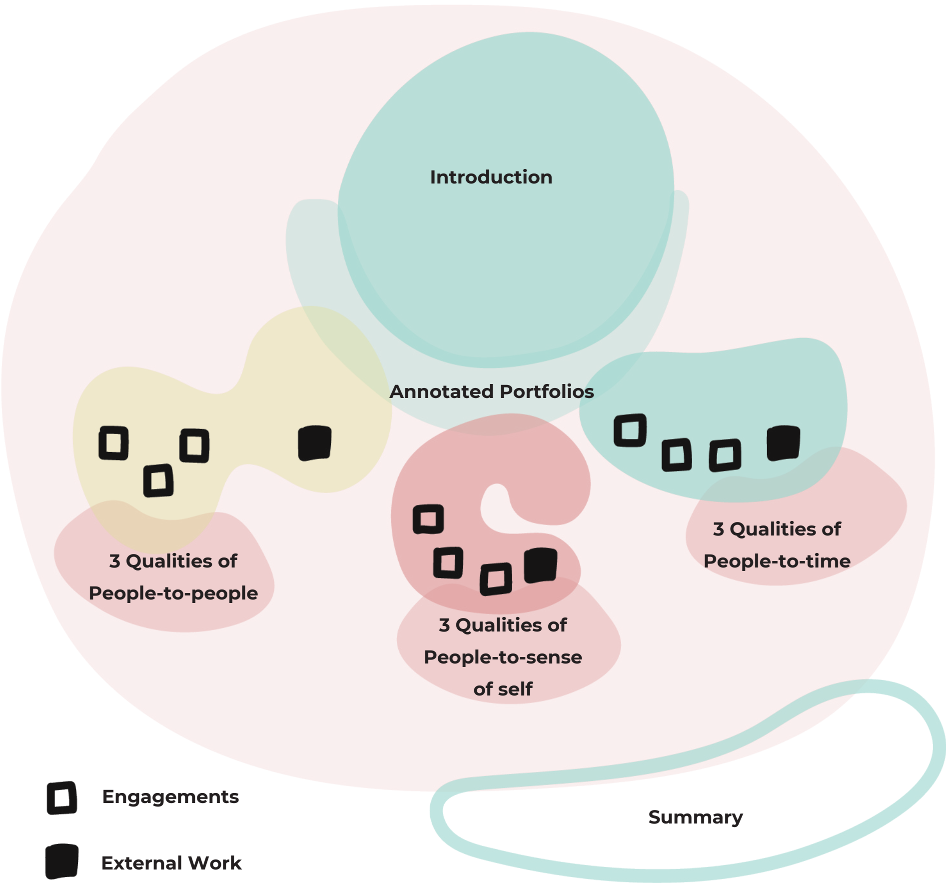


Figure 20: An overview of the three annotated portfolios and how the qualities from each are connected. This current section is the introduction, followed by a re-introduction to annotated portfolios. Then each annotated portfolio is presented as three of my engagements, and one external engagement, and the three qualities are extracted from each.

Three annotated portfolios

As previously introduced, annotated portfolios are becoming more popular in research through design (Gaver, 2012), (Bardzell, Bardzell, and Hansen, 2015) (Padfield, Löwgren and Hobye 2013) (Gaver & Bowers, 2012) and are described by Gaver as "a collection of designs" which compare "articulations of the issues, values and themes which characterise the relations among the collection" and which "maintain the particularity of individual examples, while articulating the ideas and issues that join and differentiate them" (Gaver & Bowers, 2012; Gaver, 2012).

In the following three subsections, I present brief annotated portfolios which act to explain each takeaway through a collection of engagements, chosen for their relevance to a particular takeaway.

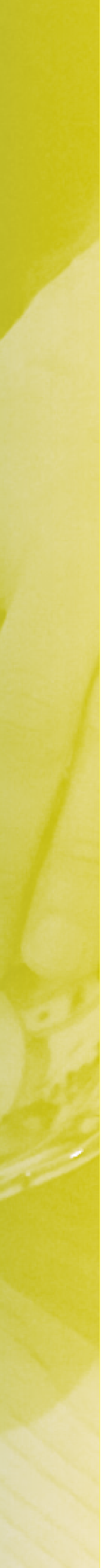
Bardzell, Bardzell and Hansen (2015) in describing research through design explain "It is through collections of multiple exemplars that themes and variations become visible, and progressive variation upon a theme is a typical way of advancing knowledge". They acknowledge Gaver's contribution to annotated portfolios and argue that annotated portfolios on their own are not enough. "Annotation of course can help render themes, variations, and their interpreted significances visible to broader audiences, helping to articulate and disseminate knowledge—but knowledge that is primarily in the designs themselves." They argue that the criticism of the academic community is needed to generate knowledge. In the annotated portfolios I present below I highlight two considerations:

1. These annotated portfolios are brief as they are presented within this dissertation as a whole, so they do not stand on their own. It is my intention that the reader has thus far come to understand the path taken to get here, and the components of the dissertation which lead to these annotated portfolios.
2. Each of the projects has been written about in a submitted academic paper. Some have been published, some have not, and all have received criticism (reviews) from the academic community.

Structure

Following, each annotated portfolio is presented as representing each one of the links. In the annotated portfolios, I present several of my engagements, highlighting how they contribute to that particular link. I compare and contrast these to one expernal project from another researcher which I have found relevant and inspirational. I may present one engagement in more than one portfolio as I find it to be the most relevant. Other engagements might also fit into this portfolio, however I have selected only the three most relevant for each portfolio.

As each of the engagements has been thoroughly presented throughout the dissertation, I focus on the "interpreted significance" (Bardzell, Bardzell and Hansen 2015) of each as it relates to the portfolio and only present the new external project. First, I outline how the engagement relates to the link, and then I explain how it is elaborated into the qualities present within that link. Then I highlight the link as a takeaway for designing for meaningfulness.



9.1 Annotated Portfolio 1

ENABLING PEOPLE-TO-PEOPLE LINKS TO FOSTER, MAINTAIN, OR STRENGTHEN HUMAN CONNECTIONS

Throughout this work, I have described people-to-people connection in relation to meaningfulness. I see this as having three qualities: developing relationships between people, deepening those relationships and creating shared identity.

Engagement 1: Fibo

Fibo, the wearable which allows the non-pregnant partner to feel the movement of the baby, has a focus of people-to-people connection. This device is a prime example of how the partner might connect to the mother through empathy and shared experience; to the baby through realization of life and recognition of movement; and potentially to society, other people - as a shift in how the role of the non-pregnant partner is viewed, as someone experiencing becoming a parent. Each of these 'societal' values emerges from interviews done with parents where they and we explored the future potential of such a device.

Engagement 2: Electronic Kintsugi

Electronic Kintsugi is a piece of broken ceramic, repaired with precious metals. When stroked, the Electronic Kintsugi emits light and sound patterns. This device, without a defined purpose demonstrates how playfulness as an interaction quality (Hobye, 2014) can act as an icebreaker, between two people who don't speak the same language, can be a momentary break from work, an intrigue, can be a part of our homes and routines, such as eating breakfast, or something to play with while exiting the apartment door after a social visit. It becomes part of how we relate to others, and share experience with them.

Engagement 3: Future Pleasure Objects

In referring to Future Pleasure Objects, I refer to the concept of a future pleasure kit overall and not any particular example: a device, in modular kit form, designed to be assembled in a way that makes sense to the person assembling it, used to explore pleasure, with themselves or with others. This kit offers an opportunity to discover with others the various forms pleasure can take; to (re)examine how one or their partner relates to pleasure and sexuality in terms of social norms and to play together, creating new understandings of body and pleasure.

External Engagement: The Mediated Body (Hobye and Löwgren, 2011)

Two people engage in a mediated experience, both wearing headphones. A performer is wearing a suit with embedded LEDs, and as the participant touches the

Figure 21: Top Left: Future Pleasure Object "Ardourino" by Kristin Weissenberger, Günter Seyfried from Pavillon35 & Doris Roth from [kat]alab. Bottom Left: Fibo user scenario. Right: Electronic Kintsugi

performer, and the performer touches the participant, sound and light is generated. Sounds evolve as the touch is changed, and only the two - performer and participant can hear the experience though anyone watching can witness a strange interaction between strangers. The performer not only wears the suit, but also costume pieces "to project a playful mindset to other potential Participants and bystanders" (Hobye and Löwgren, 2011).

Hobye and Löwgren describe the relationship between performer and the suit as "symbiotic" and explain that "the complexity of the performance combined with the interactive soundscape aims to create an intimate and immersive experience for the Participant to explore and engage in, together with the Performer." (2011).

This final engagement example demonstrates how, in this case, people-to-people connection can be about physical touch, about shared experience, and about rapidly developing trust since touching a stranger breaks social norms as Hobye and Löwgren explain in their work (2011).

Qualities of enabling people-to-people links to foster, maintain, or strengthen a human connections:

1. Developing relationships between people
2. Deepening those relationships
3. Creating shared identity

1. Developing relationships between people

For smart products to facilitate developing relationships between people requires that people are engaged with the product, whatever it may be. My focus lies in how the use of the smart product encourages further engagement, discussion, and the development of a relationship. In other words, more than the initial establishment of a relationship.

With Fibo, one example is the relationship between partner and baby which might be unusual at first, trying to relate to the movements of the baby, and calibrating one's thoughts to realize over time, that you are now a parent, and this small human is growing, becoming stronger, and moving more each day.

With Electronic Kintsugi, two people interacting with it might initially form a bond because of their shared interaction, and with the case of the English speaker versus the Danish speaker, it provides a way for them to exercise that relationship without their language interpreter.

Future Pleasure Objects similarly opens for discussion about new aspects of bodily exploration, and possibly between sexual partners, and also between non-sexual partners.

With Mediated Body, an initial interaction is established but quickly the performer and participant become interdependent on the experience, and while the performer has tried the suit many times, they allowed for "improvisation and for creating an experience in-the-moment" (Hobye and Löwgren, 2011) with the participant, which becomes a micro-relationship development, as the two explore together.

This aspect of exploration is common in all the engagements, a common exploration leading to the formation of, and development of a relationship.

2. Deepening those relationships
As a natural progression of the development of the relationship, the previous examples already begin to outline how the relationship deepens. Exploration leads to findings and hopefully, understanding. With Electronic Kintsugi, perhaps the English and Danish speaker find ways of collaborating to form new sounds, or realize they can add new elements in such as liquid to change the experience and deepen their relationship through this shared experience.

WIth Mediated Body, the performer and participant might become co-performers putting on a show which sometimes resulted in others lining up to try the experience, changing their relationship from one of introductions to one of being able to demonstrate the interaction scenario to others.

In the case of Fibo, we can look to the relationship between the mother and the partner and how that potentially changes as the partner's empathy grows, and they begin to feel a sense of what the mother is going through. The aspect of adding complexity to these relationships and interactions allows them to evolve; without further 'deepening' they would remain stagnant and might not be as interesting.

3. Creating shared identity
By deepening the relationships, and exploring, a sense of shared identity could emerge. Future Pleasure Objects offers an opportunity to explore aspects of pleasure together and create a new identity of what it means to give and receive pleasure. For Electronic Kintsugi, it might be about the aspect of the home, and how an enchanted everyday object augments the space and changes the way people use the home and objects within it, such as eating cereal from the Electronic Kintsugi bowl. With Mediated Body, the performer becomes participant, and participant performer, sharing the identity of the ones 'standing out' and breaking social norms.


LED
VDD
OUT
GND

9.2 Annotated Portfolio 2

ENABLING PEOPLE-TO-SENSE OF SELF LINKS TO TELL OR ENABLE STORIES AND THUS, HELP TO BUILD IDENTITY

Throughout this work, I have described a personal development in relation to meaningfulness. I see this as having three qualities: self exploration, self development and self expression.

Engagement 1: MusicFabrik

MusicFabrik, the music creation cover for a portable Bluetooth speaker, allows people to express themselves creatively and musically. Even as a simple prototype, early user testers were able to imagine scenarios of use, taking it outside on a nice day to play in the grass, coming home from work and picking it up to unwind. Its ability to be spontaneously played opened up for a multitude of use scenarios.

Engagement 2: Muscle Minder

Muscle Minder, the muscle squeezing device which aids in creating a mind-muscle connection before exercise, helps people to connect with their bodies. Moving beyond a visual connection of checking posture, it has the potential to interrupt the flow of thoughts, to say, what is happening here, with this squeeze? It puts focus on the muscle directly and gives the person a chance to consider what that squeeze means to them.

Figure 22: Top Left: .TIBA. Bottom Left: Muscle Minder. Right: MusicFabrik.

Engagement 3: .TIBA

As a person, newly diagnosed with Diabetes, attempts to recognize habits within their daily routine, .TIBA acts as a way for them to record not only the occurrence of this habit but also the intensity of the feeling associated to that habit trigger, such as tiredness. .TIBA, as a system (with the motivational text messages) acts as a training tool, helping people who are in the first few months of diagnosis, to develop a way to recognize their triggers and begin to form new, healthier habits.

External Engagement: LivelyButton (Larsen and Hedvall, 2012)

Situated in the context of a Snoezelen centre for children with profound cognitive disabilities, LivelyButton is part of a series of engagements aimed at engaging the children, providing "stimuli and arousal that enables the child to find the calmness or impetus she or he needs to engage in the world" (Larsen and Hedvall, 2012).

LivelyButton is a small black box with a membrane on one side. Within the box, two spirals move as the box is touched, and LEDs glow through the membrane. It reacts when touched, the motors moving the two spirals and the lights changing providing a visual and tactile experience.

LivelyButton demonstrates self development in terms of how the children reacted to it, and grew through the use of it, Larsen, in his dissertation on the topic, describes a child: “Niklas lowered - for once - his gaze and reached for the box.” (Larsen, 2012, p. xvii). Larsen and Hedvall describe: “We have also seen very significant developments with children showing unprecedented attention span and self-initiated actions.” (Larsen and Hedvall, 2012).

Qualities of enabling people-to-sense of self links to tell or enable stories and thus, help to build identity:

1. Self exploration
2. Self development
3. Self expression

1. Self exploration

Self exploration might also be called personal development, or at least, the initial stages of it. However, similar to *developing* versus *deepening* relationships, self exploration is only the initiation of self development as I have experienced in working with the engagements. The aspect of self exploration can be seen in MusicFabrik as someone begins to define themselves as a musician, or at least, loop creator; and discovers which ways of working with MusicFabrik make sense for them, as described, outdoors on a warm day, or as they arrive home from work.

With Muscle Minder, as a person uses this device, we imagine that they would begin to become more aware of their muscles and perhaps not need the device after some time, or perhaps it is an ongoing useful tool for bringing focus back to the muscle. Either way, it acts as a catalyst to provoke a question of what the person is focused on, is it their muscle and the movement, or a distraction in the gym? For .TIBA, the act of identifying triggers is the first step in discovering how to recognize them when they happen and begin to change habits. With LivelyButton, the child is able to do an action they have done many times before (push a button, touch a surface) but this time, it reacts, and they can explore further; playing and engaging more. Larsen (2012: p.197) describes how LivelyButton “entailed a feel of succeeding”.

Self exploration initiates a discourse in a new topic, whether that be an activity or a feeling. If continued, it may lead to self development.

2. Self development

Self development is the aspect of personal development I introduced in the Mechanics of Meaningfulness. Throughout my engagements, it is when a conclusion of some sort is reached and the result is a micro-step forward in the development of the self. As introduced earlier, personal development might encompass aspects of culture, values, social requirements and perspective and this is a complex topic. In reflecting on the presented engagements within this link, I can point to MusicFabrik as providing new skills, and opportunities to change practices such as changing ones habit from coming home from work and turning on the TV to coming home and playing MusicFabrik. Thus, learning or improving a new skill. For

.TIBA, as a person starts recognizing their triggers and adapting their mindset and behaviours they change habits which negatively affect them for habits which positively affect them. As Larsen and Hedvall alluded to, LivelyButton and the other engagements they explored have the potential to significantly contribute to development in terms of attention span and self-initiated actions (Larsen and Hedvall, 2012).

Zimmerman in particular introduces how interactions with products, and specifically, product attachment, leads to stories which build up identity and thus, develop the self into “the person they desire to be” (Zimmerman, 2009). This interaction with products is precisely what I refer to here, how people engage with products leads to the stories they create about themselves - I use MusicFabrik each day when I get home, and thus, I become a musician. These products, as Zimmerman explains, represent “who they were, who they are, and who they want to be”.

I’ve found personal development to be an important aspect of designing for meaningfulness, and as has been introduced, is closely tied to eudaimonia, and sense of fulfilment in life.

3. Self expression

Many of the engagements in this dissertation and the projects presented in creative drifting explore aspects of self expression, and has been important in the generation of new knowledge. By expressing oneself, one is generating new knowledge to some degree; creating a new musical loop with MusicFabrik brings that loop into the world and provides an opportunity for the musician to exercise their creative and musical muscles, sharing something with the world. This also ties into identity, expressing oneself is a statement of identity, I am this person who does/makes this thing. With Muscle Minder, the person exercising is a person who focuses on their muscles while exercising, if they are a physiotherapy patient, they use a mind muscle connection to help heal themselves; they are a person who does their exercises with intention. With .TIBA, as discussed, they become someone with good habits who can recognize their triggers and they (potentially) become Diabetics who live as close to a ‘normal’ life as possible.

This aspect of self expression contributes to a sense of identity. Through self exploration, one might discover interests, likes, dislikes, and values which were not yet explicit; through self development, one can expand upon these discovered qualities and grow those which contribute to their sense of self as per Zimmerman (2009). Finally, by expressing oneself, there is a combination of self exploration and self development, one is expressing the qualities in order to develop these qualities further.

9.3 Annotated Portfolio 3

ENABLING PEOPLE-TO-TIME LINKS TO ALLOW FOR REFLECTION AND THE MAKING OF MEANING

The final takeaway is concerned with the aspect of *time*. This has been touched upon throughout this dissertation, firstly with the reference to hedonic (immediate / short term) and eudaimonic (long term) (Mekler and Hornbæk, 2018) and also the aspect of temporality (Vallgårda, 2015) and slow design (Hallnäs and Redström, 2001). The three qualities which are present in this portfolio include: momentary versus long term engagement; the sense of time; and the representation of time in device experiences. In naming meaning making here, I refer to *interpreting* experience and reflection. This meaning, this interpretation is similar to how museum visitors came to reflect on their encounters with museum artefacts in Alelis, Bobrowicz and Ang's work wherein visitors were "motivated to find meaningful and personal connections" through reflection of their emotional responses to the museum artefacts (2013).

Engagement 1: Trækvejret

Trækvejret, as a guide to slow breathing which does not record or otherwise quantify the user's breathing, instead offers itself as a guide and then it is up to user to be aware of their own breathing and actively practice this breathing. The user, in their own time, teaches themselves to practice taking deep breaths, and this learning can happen over a period, until it becomes second nature, like brushing one's teeth.

Engagement 2: Electronic Kintsugi and MusicFabrik

Both Electronic Kintsugi and MusicFabrik offer musical experiences wherein the user can engage as much as is interesting to them, they can engage as a brief interaction of a few minutes or sit for hours and explore the qualities of Electronic Kintsugi or craft loops on MusicFabrik. Further, their expertise with the devices would develop over time.

Engagement 3: Fibo

Fibo, the pregnancy wearable, represents the aspect of the progress of time. As time elapses, the partner connects to baby and to mother. As the baby kicks and moves more over time, the partner learns more about what the mother experiences. Perhaps after a day the experience is exciting, after a week, it becomes the norm, and after two weeks, it becomes tiresome, or perhaps something to analyze and investigate patterns (we don't yet know, we can only speculate). The aspect of time plays heavily upon Fibo as the expectant parents learn more about becoming parents.

Figure 23: Top Left: Electronic Kintsugi. Bottom Left: Fibo. Right: Trækvejret.

External Engagement: Threads - A Mobile Sewing Circle by Kristina Lindström and Åsa Ståhl (Lindström and Ståhl, 2012)

Threads is a travelling collaborative work wherein participants at each stop contribute to an embroidery project involving a variety of technology based inputs and tools. A kit including an embroidering machine with the ability to receive and embroider SMS messages was part of the Threads setup. Threads would be setup and then worked on at each stop, and at each stop, become "entangled" in the participant's lives. (Lindström and Ståhl, 2012)

Lindström and Ståhl describe how time plays a factor in Threads: "Even though Threads is a temporary gathering, in the sense that the participants do not necessarily share a past or a future, the assembly as well as the participating actors, humans and non-humans, are not without a past or a future." (2012).

They describe Threads as a temporary assembly (explained earlier in Chapter 7) wherein Threads can be an in-the-moment experience as it arrives, engages and leaves. It also encompasses the pasts of the participants and their futures after participating in the sewing circle. In this way, the aspect of time is represented in several dimensions, past, present and future, and how the experience exists and then doesn't, physically, and yet, leaves an impression.

Qualities of enabling people-to-time links to allow for reflection and the making of meaning:

1. Short versus long term
2. Sense of time
3. Representation of time

1. Short versus long term

The aspect of short versus long term was introduced by Mekler and Hornbæk when discussing hedonic versus eudaimonic qualities (2018). If, as Mekler and Hornbæk explain, hedonic interactions despite their short term engagement can be meaningful, and eudaimonic ones consider a lifelong sense of fulfilment, then the aspect of time has significance for meaningfulness. In the short term, meaningfulness can be experienced hedonically, perhaps as an immediate reaction such as the first feeling of Fibo moving against the skin and feeling one's baby move; or the initial delight when caressing the Electronic Kintsugi bowl, or the satisfaction of making one's first loop with MusicFabrik. For Threads, the short term quality was that of temporarily assembling people who do not necessarily share a common history or "who do not necessarily belong to an already existing community or network" (Lindström and Ståhl, 2012).

In the longer term, Fibo could deepen relationships between mother and partner, and a deeper understanding of, and connection to the baby. Further, we look forward to finding out how people react to it after extended use, if the partners continue to wear it after a week or so, if it continues to be interesting and relevant for them. For Electronic Kintsugi, as the interaction becomes progressively more complex with use over time, this aspect of time means that it might be more interesting to engage with it over time, and discover the potentials of long term interaction (which we don't even know yet as we haven't interacted with it on a daily basis over an extended period of time). For MusicFabrik, more time engaging with it means more time to learn how to make loops, and how to create loops which function well, and perhaps even create entire compositions of music. Finally, for Threads, the longer term impact is that of the resulting communities of people who joined the travelling sewing circle, and as Lindström and Ståhl explain: "Within the framework of the project there are no demands for long-term engagement. This does, however, not mean that the assembly has no future. As the things produced in the sewing circle travels with the participants, they might become part of new conversations and relations." (2012).

The aspect of short versus long term time scale invites designers to consider how their designs can offer different opportunities for meaningful experiences; short term or longer term, applying to a hedonic, gratification based nature or a eudaimonic, fulfilment based one.

2. Sense of time

How one feels the passing of time is a question which extends beyond the scope of this dissertation, however within HCI, the sense of time passing is acknowledged by Hallnäs and Redström in their description of slow technology, "A key issue in slow technology, as a design philosophy, is that we should use slowness in learning, understanding and presence to give people time to think and reflect." (2001). They describe a doorbell, which plays fragments of a tune over progressive pressings of the doorbell. This aspect of short term (1 door bell press) versus long term (eventually hearing the entire tune) is what can give people this time to learn, understand, think and reflect. Recalling Zimmerman (2009) who looked at past, present and future selves, it is this relation to time, whether short or long which can be a consideration for designing for meaningfulness.

3. Representation of time

Unlike a fitness tracker, which in many cases, immediately displays statistics such as steps taken or heart rate, these engagements present progression or achievement through experience, it is felt and interpreted by the user rather than explicitly stated. Trækvejret may enable the observer (not even a "user" here, as all they do is observe) to reflect on, and practice their own breathing and train themselves to breathe more deeply. It is a matter of attention and self discipline. Interestingly the students from the jewellery design program described a spin-off concept from Fibo: a ring which mapped the movements of the baby over the third trimester which would be given as a gift to the mother after birth. This, is a representation of time following the use of Fibo over the final three months of pregnancy. MusicFabrik does not have a tangible or visual or non visible representation of time, instead, it is up to the user to grow their skills with creating loops. With continued use, Electronic Kintsugi offers more complexity, and this represents the passage of time and use, a bit like Hallnäs and Redström's doorbell (2001). Threads demonstrates a representation of time through the stories it tells as it moves from place to place, and the stories told by participants during the sewing circles create a representation of past (their stories), present (sharing the stories) and future (remembering, learning from and future sharing of these stories).

Furthermore, as explored in Carpenter and Overholt (2018), the temporal engagements with technology as experienced with jewellery devices allow for a different understanding of time, wherein one uses a smart product for one purpose and then puts it back again, unlike with a typical always-on smart watch. In this instance it is not time passing or past, present or future but rather when it is appropriate and useful to use this smart product, asking: is now the time to engage with this device?

By representing time through interpretive experience, one can design for meaningful experiences by providing opportunities to experience this time passage, time reflection and timely use of devices.

9.4 Summary

To summarize the three annotated portfolios, I provide a list here of each link and the associated qualities.

1. Enabling people-to-people links to foster, maintain, or strengthen human connections
   a. Developing relationships between people
   b. Deepening those relationships
   c. Creating shared identity

2. Enabling people-to-sense of self links to tell or enable stories and thus, help to build identity
   a. Self exploration
   b. Self development
   c. Self expression

3. Enabling people-to-time links to allow for reflection and the making of meaning
   a. Short versus long term
   b. Sense of time
   c. Representation of time

10

DISCUSSION

10 DISCUSSION

In this chapter I elaborate on concepts which have been present throughout this dissertation and which for me, come together as a way of reflecting back on what it is to design for meaningfulness. I first revisit self reliance as a theme which emerged subtly but consistently throughout this dissertation. Then I continue to reflect on the timeliness of this topic from an academic and industry perspective. I re-examine the confusion around terminology and reflect on how people nonetheless, engaged with the engagements and how this leads to an invitation for researchers to expand upon and define designing for meaningfulness. Finally, I present the limitations I have encountered and those which have framed my work; and present opportunities for future work which I believe is important to make designing for meaningfulness a useful and important part of HCI.

10.1 Self Reliance as a Red Thread

Self reliance has emerged as a theme throughout this dissertation in terms of people being responsible for their own development. The partner has to be willing to experience Fibo and draw their own conclusions, the people observing Trækvejret have to practice breathing and make it a habit, the people using .TIBA have to recognize their triggers, record, and change accordingly, etc. Mekler and Hornbæk in analyzing eudaimonic versus hedonic qualities reported on the quality of attribution: "hedonically motivated users were more likely to credit the interactive technology as the direct source of their positive experience" and "the fact that eudaimonia and attribution were not correlated suggests that even if instrumental aspects did facilitate the positive experience, participants seemed not to consider these aspects the actual cause of their positive experience." (Mekler and Hornbæk, 2018).

This to me, doesn't mean that devices are irrelevant. Rather, it means devices are the catalyst.

> Smart products, designed for meaningfulness, have the potential to give people an opportunity to practice self reliance.

The cause of their meaningful experience is themselves, reacting to the *catalyst* of interacting with the smart product.

People can:

FIBO
Share an experience and reflect on what it means to be a parent and a partner, and *then* identifying as a parent earlier, changing habits, attitudes and relationships.

ELECTRONIC KINTSUGI
Question how they relate to everyday objects and craft, identifying what is important to them, which objects are of emotional value and which provide opportunities for engagement, for reflection, or for action and *then* engage with those with a purpose of developing.

TRÆKVEJRET
Observe a slow rate of breathing each time they go to get a coffee and *then* teach themselves to take a slow deep breath several times throughout their day.

MUSCLE MINDER
Feel the tightening on the muscle reminding them to have a mind-muscle connection and *then* make that connection, focus, and do it for the sake of their development, physically and mentally. Further, like Trækvejret, they might train themselves to do it automatically.

MUSICFABRIK
Play the interactive speaker cover, creating loops, be playful, be creative and *then* create habits such as coming home and unwinding, and expressing yourself creatively, evolving into a musician.

.TIBA
Teach themselves to recognize a trigger (for example, hunger) and the level of intensity of the feeling and *then* teaching themselves better habits through recognition, acceptance and behaviour change via self discipline.

FUTURE PLEASURE OBJECTS
Begin to build and experiment with DIY kits and *then* identifying what is pleasurable to them, how their bodies respond, how they relate to the concept of pleasure, and if applicable, how their partners or non-sexual partners also relate to pleasure.

In each case, the smart product acts as a catalyst, an opportunity to engage and take action. What results is entirely up to the person engaging with it. Their experience is their own, their takeaway is their own.

Whether or not this contributes to a sense of meaningful experience, be it personal development, moments of significance, value, discovering meaning in everyday life, or critically thinking, or something that I haven't thought of, but perhaps other researchers are pondering and bringing to light in the future, is *entirely up to them*. I cannot take responsibility for a person's experience. I can only design for them to engage, evaluate and evolve, if they so choose.

10.2 Meaningfulness is Timely and Relevant in Industry and Academia

As introduced in the theoretical drifting chapter, the topic of meaningfulness has been hovering near the surface of research; with values which are similar to those in other recent domains such well-being (Diefenbach, 2017), happiness (Hassenzahl et al., 2013), reflection (Mols, Hoven and Eggen, 2016), authenticity (Su and Stolterman, 2016), positive design (Desmet and Pohlmeyer, 2013), hedonic and eudaimonic design (Mekler and Hornbæk, 2018), and in domains outside of HCI, such as jewellery design (Ahde-Deal, 2013). These values point towards designing smart products which enable people-to-people and people-to--sense of self connections and critical thinking.

As discussed, many of these mention the term 'meaningfulness' or refer to it implicitly and few explicitly refer to meaningfulness, or if they do, it is within the context of another study such as Ghellal (2017) who discusses meaningfulness in relation to technology use, but focuses on ambiguity or prescribed qualities as factors in the design of transmedia experiences. Mekler and Hornbæk (2018) are in a very similar track as designing for meaningfulness however, their focus is on analysing the differences between hedonic and eudaimonic experiences. Mekler and Hornbæk's work is extremely relevant for my own, and for me, these two examples, especially the latter, point to meaningfulness as being relevant in academia right now.

Further, the examples I have provided of academic research which either alludes to meaningfulness, or directly uses the term, demonstrate a tendency towards exploring meaningfulness in its own right within HCI.

Within industry, there has been significant interest about designing for meaningfulness. From August 2016 (when I began to know something more about this area) to July 2018, I have spoken at the following events about designing for meaningfulness. To clarify, I have been invited to speak about it, emerging from interest from industry:

- Wearable Technologies 2018, San Francisco
- Hackaday Belgrade 2018, Belgrade
- Health and Rehab Messe, 2018 with the Danish Technological Institute, Copenhagen
- IxD After Dark - Aalborg
- The Curie Network for Ambitious Women in Business and Technology
- Welfare Technology, Kickoff

event 2017, Hørsholm
- High Tech Summit 2017, DTU, Lyngby (Fibo + Designing for Meaningfulness)
- TechBBQ 2017, Copenhagen
- SummIT, Future Outlook - Spot på fremtidens hotteste teknologier 2017, Copenhagen
- Sketching in Hardware 2017, Detroit
- The Engineer Society of Denmark, Copenhagen
- Driving IT 2016, IDA, Copenhagen
- Danish Design Centre
- Underbroen

In each of these talks, people working in industry have been curious about how they can utilize this in the design and development of their smart products. This interest led to a project with Welfare Technology called Innovation Health and Welfare in Designing for Meaningfulness. This 1.5 year project was done during my PhD and engaged companies in a series of seminars, workshops and case studies to explore how they might benefit from designing for meaningfulness. This was awarded 650.000 Danish Kroner, the largest amount awarded to any GTS (Godkendte Teknologiske Serviceinstitutter) in this program. This investment demonstrates how industry is interested in this area, and how it is seen as an important factor in current industrial research.

I have also been trying to communicate what I have learned throughout my research to industry by writing a blog on the online platform, Medium and posting these articles to LinkedIn. While I do not yet have a wildly successful following (nor have I invested any time into cultivating a following), each article does receive an average of 40 reads on Medium and announcements of talks and events receive ca. 2000 views on LinkedIn which I take to be some indication of interest in what I am writing and speaking about.

I feel that the interest in the form of invitations to speak about the topic at industrial events combined with the funding received to explore this area, and the commitment from various companies to spend time on workshops, and the initial interest of my blog posts suggests that this is a relevant topic for industry.

10.3 Interaction with Engagements, Terminology and Imagining the Future

The engagements as very early sketches, acted as research vehicles for unearthing and exploring the Mechanics of Meaningfulness and the Manifestations of Meaningfulness which might be relevant when designing for meaningfulness. This was useful as an aid to define the term meaningfulness in my work. I knew what I meant on a gut feeling level; I have been working for 15 years with interactive devices of some sort or another, and throughout this, as can be seen by the creative drifting presented (with a humble but important reminder that this is only a selection of projects from each domain, and not all of the projects I have been working on) I have come to some understanding of what is lacking in industry. Upon re-entering academia after a hiatus since my Master's degree, I realized that while physical and tangible computing have firmly established themselves, and a variety of other sub disciplines have emerged (such as the twelve presented in Chapter 5.2: Theoretical Drifting), the same things that I was curious about in industry were also not explicitly being discussed in academia.

By creating the engagements, I was able to explore the formation of a hypothesis and asked myself, could I define some parameters which other researchers could further explore about meaningfulness, as per my definition of it? I developed the Mechanics of Meaningfulness and the Manifestations of Meaningfulness as an exploration of the potential parameters of designing for meaningfulness. Through insights and intermediate level knowledge gained during the development, and reflection upon these engagements, I developed these parameters and hereby present them as a starting point for further research into designing for meaningfulness.

I acknowledge that many, if not most, of the domains I presented in Chatper 5.2: Theoretical Drifting, might result in designing for meaningfulness. For example, Hassenzahl is presented as designing for happiness, and his research extends tremendously in this area, to the point where he has an entire group dedicated to the study of experience and interaction design in this area[1]. I expect that he has certainly covered aspects of designing for meaningfulness in his extensive research. However, I argue that Hassenzahl along with the others I have presented, have not explicitly done research within designing for *meaningfulness*.

Given the prevalence of the term meaningful throughout various works, I find a gap in here that I hope this dissertation points towards; the gap of explicit research in designing for meaningfulness.

I imagine part of the reason for this gap is the confusion around any part of the terms meaning, meaningfulness, or meaning-making. There are countless interpretations of this term and a variety of ways in which it is used, nevermind the complexity of the English language using this root word of 'mean' to mean so many different things, as an adjective it refers to being unkind. As a verb it can refer to intention to convey something, (as we are doing in this sentence), intending something to occur, *I mean for this to happen*, or to have a consequence, this will *mean* that. Therefore, why people are confused when it comes to the word meaningful, is rather understandable. They put their own meaning into it.

1 *http://www.experienceandinteraction.com/*

Companies working in healthcare have often told me how their products are meaningful because they save lives. In academia, I've seen countless references to how an interaction with technology was meaningful for someone (referring to significant) or how statistical results are meaningful. Yet, somehow when I explain what I mean to people, and use the term "designing for meaningfulness", people seem to understand it and appreciate it; there has generally been a positive reception within industry though not as positive within academia, and I believe this is due to the lack of clarity in the term. In our workshops with companies, most of them rated themselves a 10 on a scale of "how meaningful is your product?". However, when presented with the nuances of meaningfulness, such as the mechanics or manifestations, they rated differently. These nuances are the interesting aspects - asking if a company considers their product meaningful or not (Carpenter and Mekler, 2018).

There is opportunity to concretely define this for different segments of smart products, such as lifestyle, healthcare, transport and logistics, and others.

Finally, it is important to ask how we bring this term into industry. With a plethora of "buzzwords" existing in the world of innovation where I work, (innovation itself being the most overused buzzword), how do we introduce a term as complicated as meaningfulness? I would imagine that through presenting the nuances of the term, clarity can be reached.
For example, "disruption" is the latest and greatest buzzword. In industry, it's nearly meaningless, with recent attempts to (further) clarify it (Christensen et al., 2018). Most understand it to mean coming up with a great product idea which changes the way people do things. Which is true to an extent. However, there is extensive academic research into the term disruption, and it does have fast and hard definitions (Christensen, 2006). I was given the example of the transportation company Uber, which is traditionally hailed as a prime example of disruption. Sidsel Ernstsen, a PhD student at Denmark's Technical University explained to me how the Uber app is not disruptive. It didn't change *that* we use taxis, it changed *how* we access and pay for them (Ernstsen et al., 2018). I can say from personal experience, this is a common misconception both on my behalf and on my peer's. I attribute this to the divide between academia and industry.

In working on both sides of the fence within this dissertation, by publishing a blog, and speaking at industry events, I hope to invite industry to join this discourse on designing for meaningfulness, and I invite other researchers to join me in clarifying these terms both within academia and for industry.

10.4 Limitations and Opportunities

This work essentially points to a gap in academia and industry where designing for meaningfulness might be a relevant, timely and useful topic. This being the case, many explorative actions have been taken; engagements have been created and deployed and insights collected and presented. Companies have been interviewed, attended seminars, presentations and in-depth workshops and have commented on my work and given feedback. And much synthesis has taken place in the form of seeking to understand the connections, the red threads and how they can be used to illuminate this gap.

However, this work only points to this gap. It provides some initial mapping of areas in the theoretical drifting chapter and it provides a set of proposed parameters, the Mechanics of Meaningfulness and the Manifestations of Meaningfulness. My intention is to point to this gap and invite future researchers to come explore the potential of this space with me, to define designing for meaningfulness for both academia and for industry.

In future research, evaluating meaningfulness in smart products is an essential component. Mekler and Hornbæk describe in their work other works which aim to quantify meaningfulness, pleasure and significance. (Mekler and Hornbæk, 2018). The works they point to and their own work in analyzing hedonic versus eudaimonic is a natural next step for this research, to expand on their work and begin to work with companies to explore how to incorporate this into their product design cycle. This has been a limitation in my own work, as I very early on proposed a framework for meaningfulness which was quickly dismissed by other researchers who were quite honestly, fed up with frameworks and suggested that I spend the time in this PhD focusing on investigating the area, and not necessarily presenting any kind of new design framework. I do not see this as a missed opportunity but rather as a future opportunity to quantify meaningfulness in smart products. During our workshops with companies towards the end of this research period we coined this *Metrics of Meaningfulness*. (Carpenter and Mekler, 2018).

My research is limited to, or said another way, tightly focused on consumer facing smart products. It excludes IoT systems such as industrial IoT applications, or non-consumer facing solutions, even if they might seem consumer facing in nature. One example of this is a project we did in IdemoLab, where we developed an energy harvesting solution for existing e-ink displays used to show prices on a shelf in grocery stores. This was incredibly 'meaningful' to the grocery store, they no longer had to replace batteries (which was done one by one every few years), they saved time, money and manpower, but it wasn't meaningful as I'm concerned with. There was no *personal* aspect in this project. Furthermore, I found that the majority of the projects we did in IdemoLab - due to the type of customers we had at the time - were of this nature - industrial IoT; so the consumer facing smart product development projects we did have are Fibo and .TIBA. It would have been useful if all my engagements emerged from company cases but this simply wasn't the reality of who IdemoLab's customers have been during this process. It is my hope that these two examples, combined with the rest of my engagements illuminate the framing of designing for meaningfulness in consumer facing smart products.

One honest and wonderful conversation I experienced was with a company who openly admitted, "Our product is not meaningful. Not in the way you mean. This product will help people to avoid re-injury, which is meaningful, it means they are not in pain, it means they can continue working, and they are less stressed, but it doesn't fulfil the criteria you have set forth". And these aspects mentioned by the company, being less stressed, being pain free, *are* meaningful to their users, so there exists opportunity to map out how meaningfulness is used by different companies in the many, many different interpretations which exist of the term.

With regards to the methodology chosen, a programmatic approach to research through design, I would like to briefly address the challenges of this approach. While it was chosen specifically for the ability to explore, investigate, and initially define some parameters (the Metrics and Manifestations of Meaningfulness), it does have its limitations. By working solely with sketches, I did not get a chance to see the long term effects of for example, Fibo, .TIBA, Electronic Kintsugi or Trækvejret. However, if I had focused on only one, I would not be able to compare and contrast across the sketches. And furthermore, none of these would have been realized in the relatively short time span that a Danish PhD offers. Fibo is still years away from being on-market, .TIBA is currently undergoing user testing for further development for market, Electronic Kintsugi is in its infancy and would require significant time with a Kintsugi artist to explore the material properties of conductivity in the traces. Focusing on one of these projects in a PhD might be interesting but my decision to follow a programmatic approach to research through design was specifically chosen because I wanted to explore a series of engagements and learn about how each of these informed the overall programme which I feel I have accomplished.

Finally, one aspect which I have encountered during late night conversations over wine with friends - both academic and others, about meaningfulness is the 'what right do you have?' conversation. As in, what right do I have, as a middle class white woman doing a PhD, to even question meaningfulness. The short answer is, I don't. And it would be another dissertation altogether to explore this topic. However, given the problems the world faces, how is it realistic, fair, or reasonable to approach this topic?

My answer to that has been to turn to the work by Light, Powell and Shklovski (2018) who ask, "how to design for the common good, focusing on human needs for meaning, fulfillment, dignity and decency, qualities which technology struggles to support but can easily undermine". Their work, *Design for Existential Crisis in the Anthropocene Age* (2018) describes how designers are part of this because our work is about the future. They present two versions of 'saving humanity', describing the very real problems we have in the world today, with everything from war, famine, resource scarcity, to global warming as just a few of the problems we need to design for. They discuss the concept of eudaimonia (as described in Chapter 5.2, Theoretical Drifting) and describe how to design for existential crisis, namely by "paying attention to things we do not wish to see" and by designing for noticing, for gratitude, for kinship.

"We can design to show the beauty of the world and to help people come to terms with the poignancy of losing it." (Light, Powell and Shklovski 2018). They explain, "If we become what our interactions make us, we risk the atrophy of the muscles we neglect, and the real range of our potential humanity is lost to us." continuing, "As designers, researchers and makers, we can help deliver tools that promote both the enduring search for a common task and the task itself, leading the process of discovering collective and personal purpose" (Light, Powell and Shklovski 2018).

Light, Powell and Shklovski beautifully address the fundamental problem that I hope designing for meaningfulness can begin to address, the problem of humanity.

By focusing less on screens, more on people, more on experience, more on self reliance, and making one's own future, discovering purpose, and seeing what we don't want to see - perhaps we can begin to see the rest of the world; perhaps we can begin to lower our collective barriers and help each other to heal the wounds this world has endured through centuries of selfishness. By reflecting on meaningfulness, and acting to become self reliant enough to be able to raise others up, perhaps we can begin to focus on what is really important, saving humanity.

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11

CONCLUSIONS

11 CONCLUSIONS

This dissertation presented a series of so-called engagements: early sketches which act as vehicles for research, exploring an area within interaction design which I call designing for meaningfulness. This was conducted in the context of industry, situated within my role for the past six years as Lead Technology Experience Designer at IdemoLab, FORCE Technology (a hardware meets user centered design lab). I explored and mapped designing for meaningfulness through a combination of literature review, generating knowledge through the creation and early evaluation of engagements (electronic sketches), gaining insights from interviews, seminars and workshops with companies developing smart products; and comparison to other academic works in similar areas. The 7 published and 3 submitted publications included in this dissertation expand on the engagements presented, situating them in relation to other academic works and extracting qualities of what I refer to as the Mechanics of Meaningfulness and the Manifestations of Meaningfulness.

This work utilizes a methodology of programmatic research through design (Löwgren, Larsen and Hobye 2013 and Redström, 2017), wherein I conducted investigations by creating artefacts which through both the making of the artefacts and the use, generated intermediate level knowledge (Löwgren, 2013) and insights. Knowledge emerged from both the engagements, as well as work with companies, past projects, and insights gained from literature. Together, these form a design research programme (Redström, 2017) wherein each component generates knowledge, forming an overall programme, which is designing for meaningfulness.

My research topic, situated within interaction design in HCI, is timely and relevant as current work increasingly point towards meaningfulness as a quality to explore (Mekler and Hornbæk, 2018), (Light, Powell and Shklovski 2018), (Ghellal, 2017) and recent work asks similar questions about designing for fulfilment through happiness (Hassenzahl et al., 2013), well-being (Diefenbach, 2017), reflection (Mols, Hoven and Eggen, 2016), authenticity (Su and Stolterman, 2016), positive design (Desmet and Pohlmeyer, 2013), hedonic and eudaimonic design (Mekler and Hornbæk, 2018), and in domains outside of HCI, such as jewellery design (Ahde-Deal, 2013).

Further, as this work is situated within industry, it is important to consider the interest from, and relevance for, industry. This interest has been demonstrated by both interest from the industry community working with smart product development who have asked me to speak or hold workshops and seminars about designing for meaningfulness in a variety of events, and by the full funding of this PhD, and further significant funding by another project which are both interested in exploring the area of designing for meaningfulness for companies developing smart products.

My research was motivated by two research questions. The first asks, how might we conceptualize designing for meaningfulness within interaction design to benefit industry who are developing consumer facing smart products? This is answered by a presentation of initial considerations for designers which I call the Mechanics of Meaningfulness. These mechanics include: *personal development, moments of significance, value over function, meaning in everyday life, critical thinking,* and *offline artefacts*. I present these considerations in the context of the seven engagements, giving examples of how the various engagements demonstrate aspects of the Mechanics of Meaningfulness and I situate each 'mechanic' within related literature to compare and contrast how these relate to academia. These are an initial set of considerations and I hope future researchers further evaluate and expand on these.

My second question asks, what might be the Manifestations of Meaningfulness (the physical characteristics) of a smart product which acts a catalyst for personal meaningfulness? To explore this, I consider each of my past projects, nine in total, and the seven engagements I created as part of this work, and present the Manifestations of Meaningfulness which designers might consider when developing new smart products. Four Manifestations of Meaningfulness: non-screen, tangible, everyday object and craft are presented in light of not only the past projects and engagements but also in relation to relevant academic literature and are further exemplified by near or on-market examples of commercially available products. These 'manifestations' are suggestions which may offer opportunities for insight for design practitioners and companies. Further, they demonstrate how we might move away from the screen as a go-to solution for new devices; how we might utilize more of our senses than simply sight and sound through tangible interaction using the rich variety of sensors and actuators available to us in a world of increasing technology; how we might consider the everyday objects around us and how we form our perception of the world through these objects and then design for them; and finally, how we might learn from the qualities of traditional craft, appreciating the preciousness (Tsaknaki, 2017) inherent in both materials and experience.

These two aspects, the Mechanics of Meaningfulness and the Manifestations of Meaningfulness are situated both academically and in industry to provide insights to both domains. These act as drivers of the greater exploration of beginning to map out the area of designing for meaningfulness. From these, I derive three takeaways for designers and explain these in a series of annotated portfolios (Gaver and Bowers, 2012). These annotated portfolios act as galleries, each exhibiting three of my engagements plus one 'external engagement', an academic work from someone else to form a research landscape, eliciting the qualities of each take-away. These takeaways act as a fourth contribution of my work, alongside the mapping of the literature leading to meaningfulness; the Mechanics of Meaningfulness and the Manifestations of Meaningfulness.

The first takeaway is *enabling people-to-people links to foster, maintain, or strengthen human connections*. Here I articulate how we might consider technology as a driver to help people connect to one another on a deeper level, through the formation of relationships, the deepening of those relationships and through creating a shared identity. While I acknowledge the role of screen based apps in facilitating relationship development, I turn the focus towards how non-screen, tangible devices might act as catalysts to help people explore the deeper emotions and values associated with their relationships.

The second takeaway is *enabling people-to-sense of self links to tell or enable stories and thus, help to build identity*. I explore how aspects of self exploration, self development and self expression contribute to designing for the self (Zimmerman, 2009) and how artefacts which enable exploration of the self both mentally and physically, which enable creative self expression, and which help a person train themselves to form habits or awareness of their actions contributes to an overall sense of meaningfulness.

The third takeaway is *enabling people-to-time links to allow for reflection and the making of meaning*. I reflect on the aspect of time in relation to the concept of meaningfulness as presented through various literature and how this relates to designing for reflection (Mols et al., 2016) or meaning-making (Jung et al., 2011). I see time as a crucial aspect, wherein people must take the time after encountering an artefact to consider their own lives, to make their own meaning and to move from a hedonic, or immediate sense of meaningfulness to a eudaimonic, or long term sense of meaningfulness (Mekler and Hornbæk, 2018). I present three aspects of time, the short versus long term (as just described), the sense of time, such as that explored in Slow Design (Hallnäs and Redström, 2001), and the representation of time, or how we represent past, present and future through the use of artefacts, leading to a possible construction of meaningfulness.

Fundamentally, I see this work as a first step in moving towards an area of research called *Designing for Meaningfulness*. I present works which implicitly refer to meaningfulness but which do not explicitly refer to it with the exception of a few. Among these few references to meaningfulness, there is a range of interpretations and presentations of the term meaningfulness, from a passing reference of a meaningful experience to an exploration of meaningfulness in a particular context, such as transmedia experiences (Ghellal, 2017). There is therefore a need to continue mapping this area, being specific about what precisely a meaningful experience in a variety of a contexts might entail and how this might lead to eudaimonia, or a life of fulfillment. I see an opportunity to define something Dr. Elisa Mekler and I propose in our pending paper (Carpenter & Mekler, 2018) called the "Metrics of Meaningfulness". Mekler and Hornbæk (2018) have already begun to explore this in their work on hedonic and eudaimonic meaningfulness where they begin to chart the various types of measurements of meaningfulness which exist in different academic domains such as psychology.

I suggest that there could be a tighter coupling between academia and industry, in that industry currently exhibits significant interest in the designing for meaningfulness and there exist many companies who are willing to discuss and experiment with designing for meaningfulness. Disseminating the vast array of work within academia which I briefly introduce in this work is a challenge; it spans many genres from philosophy to psychology to hardware focused interaction design to speculative design amongst other genres, and is not in a easily accessible format for industry. Not only is it often behind the walls of academic access such as the ACM Digital Library; but the language used is restricted to academics who also speak this language and there is not an adequately clear and concise way to discover works - with few exceptions such as the Personal Fabrication Research in HCI and Graphics Overview[1]. In creating this dissertation, significant work was conducted to discover literature which related to this subject, and a strong background of interaction design was necessary to sort between literature which is not necessarily relevant for industry such as those exploring important issues for academics in design theory (such as Höök and Löwgren 2012) and those which contain practical information which industry could use without necessarily having a background in academia (and specifically in HCI) (such as Desmet and Pohlmeyer, 2013). I therefore propose that future work includes further dissemination of knowledge to industry, as I have begun to do through presentations, seminars, workshops, the writing of a blog on Medium (or another similar platform) and individual consultations with companies.

As a concluding statement, I sincerely hope this work contributes to further practices in research through design, creating artefacts which help academics and industry to explore the vast array of sensors

1 *https://hcie.csail.mit.edu/fabpub/*

and nearly endless options for actuators in designing new smart products which contribute to a world wherein we are more aware of our actions, relationships, sense of self and how we relate to the world. This relation to the world is vital; so much new technology is based solely on convenience or novelty and in a world where we are are approaching billions of IoT enabled devices (Statista, 2018) there is a critical need to be conscious of what we are designing and what impact that has on people.

My hope is that by focusing on designing for meaningfulness, we ask ourselves if the consumer facing device we are creating is really, truly needed in this world, and if it contributes to a world where people become more empathic, making life better not only for themselves, but importantly, helping others to achieve meaningfulness in their lives.

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APPENDIX

THE APPENDIX CONTAINS THE WORKSHEETS USED FOR THE DESIGNING FOR MEANINGFULNESS WORKSHOPS WITH WELFARE TECHNOLOGY COMPANIES AS INTRODUCED IN CHAPTER 7. THE FOLLOWING WORKSHEETS INCLUDE:

DESIGNING FOR MEANINGFULNESS

Mechanics of Meaningfulness

Values

Prioritize - choose which values to discuss (1 - 6)

1. Personal Development
   a. How does it contribute to a sense of identity?
      i. Who am I in this moment?
      ii. Who have I been?
      iii. Who do I want to become?

2. How does it help establish personal values?
   a. I am someone who ...
      i. Is responsible
      ii. Is kind
      iii. Is conscious of others

3. How does it contribute to moment of significance?
   a. Is there a sense of discovery when using it?
   b. How does it facilitate personal transformation?
   c. How does it facilitate an ‘ah-ha’ moment?

4. Value over function:
   a. How does it offer more than convenience?
   b. What are the emotional values that the function allows for?

5. Meaning in everyday life:
   a. How can it adapt to fit what we need in a given moment?
   b. If we should focus on right now, instead of the past or the future, how does it help us with our current selves?

6. Critical Reflection:
   a. How does it make us reflect on ourselves and our actions?
   b. Is this product truly needed in the world?

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DESIGNING FOR MEANINGFULNESS

Components of the Experience of Meaning

Purpose

- Does the product help users identify personally important goals?
- Does the product help users set manageable small er goals to reach those personally important goals?
- Does the product support users in reaching and achieving those goals?

Coherence

- Is it clear to the user how the product connects to their life?
- Does the product make sense to the user?
- Does interacting with the product feel right to user?
- Does it click with them?

Significance

- Does the product matter to users beyond the momentary interaction? How so?

Contact

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DESIGNING FOR MEANINGFULNESS

Manifestations of Meaningfulness

Physical Characteristics
Non Screen

- Does the product have a screen or an app?
- Why does it need this?
- Have you considered a non-screen approach?

Tangible

- What are the physical characteristics of holding and engaging with this object?
    - o How does it interact with the body?
    - o How does this make us relate back to the values of meaningfulness?

Everyday

- Is this an everyday object?
    - o Do we use it every day or only once in a while? (Such as a pair of cufflinks we wear out on a special occasion versus a spoon we use every day for breakfast)

Craft

- How does this relate to traditional craft?
    - o Was it handmade?
    - o Do customers know the origin of the materials?
    - o Does the way it was made tell a story?
    - o Was there an artist or crafts person involved?

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DESIGNING FOR MEANINGFULNESS

From Better Things

www.betterthin.gs

Your Product/Service:

1. How is it essential?

2. How does it solve a problem?

3. How does it provide information?

4. How is the information actually actionable?

5. How does it have more than one use?

6. How does it add beauty to your life?

7. How does it make us smarter?

8. How does it make you feel better, emotionally?

9. How does it create a sense of wonder?

10. How does it make its user's life more convenient?

11. How is it art?

12. How does it make me a better person?

13. How does it do something that humans find either:
    a. Dirty
    b. Dangerous
    c. Dull

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DESIGNING FOR MEANINGFULNESS

HEMA Questions About Eudaimonic Experience

Please rate on a scale from 1 - 10 how much you disagree (1) or agree (10) with the below statements. This is from a study by Huta & Ryan*

To what degree would users approach your product with each of the following intentions?

1. Seeking relaxation?

1	2	3	4	5	6	7	8	9	10

2. Seeking to develop a skill, learn, or gain insight into something?

1	2	3	4	5	6	7	8	9	10

3. Seeking to do what you believe in?

1	2	3	4	5	6	7	8	9	10

4. Seeking pleasure?

1	2	3	4	5	6	7	8	9	10

5. Seeking to pursue excellence or a personal ideal?

1	2	3	4	5	6	7	8	9	10

6. Seeking enjoyment?

1	2	3	4	5	6	7	8	9	10

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7. Seeking to take it easy?

1	2	3	4	5	6	7	8	9	10

8. Seeking to use the best in yourself?

1	2	3	4	5	6	7	8	9	10

9. Seeking fun?

1	2	3	4	5	6	7	8	9	10

10. Seeking to contribute to others or the surrounding world?

1	2	3	4	5	6	7	8	9	10

11. Seeking to have things comfortable?

1	2	3	4	5	6	7	8	9	10

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* Huta, V. and Ryan, R. M. 2010. Pursuing Pleasure or Virtue: The Differential and Overlapping Well-Being Benefits of Hedonic and Eudaimonic Motives. Journal of Happiness Studies 11, 6: 735-762. https://doi.org/10.1007/s10902-009-9171-4

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DESIGNING FOR MEANINGFULNESS

Huta - Meaningful Experience Scale

Please rate on a scale from 1 - 10 how much you disagree (1) or agree (10) with the below statements. This is from a study by Huta *

"This activity / experience / product / whatever felt ..."

Meaningful

1 2 3 4 5 6 7 8 9 10

Full of significance

1 2 3 4 5 6 7 8 9 10

Making a lot of sense to me

1 2 3 4 5 6 7 8 9 10

I could see how they all added up

1 2 3 4 5 6 7 8 9 10

Valuable

1 2 3 4 5 6 7 8 9 10

Precious

1 2 3 4 5 6 7 8 9 10

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Something I could treasure

1	2	3	4	5	6	7	8	9	10

Dear to me

1	2	3	4	5	6	7	8	9	10

Playing an important role in some broader picture

1	2	3	4	5	6	7	8	9	10

I could see where they fit into the bigger picture

1	2	3	4	5	6	7	8	9	10

They contributed to various aspects of myself

1	2	3	4	5	6	7	8	9	10

They contributed to my community and broader world

1	2	3	4	5	6	7	8	9	10

* Huta, V. (2017). Meaning as a subjective experience. Journal of Constructivist Psychology, 30(1), 20-25.

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PAPER 1

PROVOKING BREATH: AN EXPLORATION OF HOW TO REMIND PEOPLE TO BREATHE

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Provoking breath: an exploration of how to remind people to breathe

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People forget to breathe. In this work, we explore the subject of breath, specifically how to remind people through subtle indicators or coaching, to remind them to breathe throughout their workday. Much research has been done into the effects of focused breathing, of deep breathing, and of a variety of breathing techniques [1]. However, on a very basic level, breathing brings oxygen to the body and with more oxygen, they have better brain function, blood flow, and overall wellbeing [2]. Studies of people working in offices, at desks, have shown that people do not focus on breathing often enough, despite the stress reducing qualities it offers and the increased focus it can provide [3]. Beyond a lack of focus on breathing, some also stop breathing or even hold their breath while sending emails [4].

Our ambition is to discover if we can encourage people in an office environment (desk work) to breathe more mindfully through persuasive interactions with extremely simple interactions. We created two prototypes, one which is subtle: an unusual, but static part of the environment, envisioned to sit beside the communal coffee machine in a 200-person office space. The second is an interactive device, training people to breathe deeply and follow a pattern of breathing. The first prototype will be explored in this work.

A variety of devices already offer breathing training, or reminding you to breathe. Apple's "Breathe" app [5] for the Apple Watch coaches you with different breathing techniques and haptic feedback and reminds you to breathe throughout the day. Fitbit [6] offers a "Guided breathing experience" through their Relax app. BreathMinder [7] trains you to breathe at a pace and reminds you to do breathing exercises. Spire [8], a small discrete wearable tracks your respiration throughout the day alerts you to when you are tense.

As opposed to requiring people to wear a device which they might not own or be interested in owning, our goal was to create something which was placed in a communal area. We are primarily interested in communal areas, which for our initial evaluation context includes a common coffee room where many people from an office building go for their coffee breaks two to three times per day.

Figure 2: The first prototype

The first prototype: (Figure 1)
A simple piece of laser cut wood, cut accordion style so it is flexible is the basis for this prototype. The top of the wood is attached to a servo motor which moves back and forth,

pausing at the ‘top’ and ‘bottom’ of the movement. As the wood is moved up and down by the servo motor, it pauses at the bottom, creating a rounded shape, and pauses, representing inhalation, a full stomach; then it returns to the top and pauses there for a longer moment, representing the space between breaths. The timing was based on the average adult breathing rate according to a website dedicated to respiratory rate information [9]. Above the flexible piece of wood was a legible inscription which said “breathe”.

This prototype was placed on top of an industrial coffee machine in the break room, just above eye level. Since the prototype was small, 12.5cm tall, it was not the primary focus when getting a coffee. When fabricating the prototype, we thought about the sound of the servo and decided that perhaps it might be either overshadowed by the sound of the coffee machine grinding and brewing coffee, or could be an intriguing method to gain attention of the person using the coffee machine. In testing it could be seen that as people waited for their coffee, they were able to hear the sound of the servo motor and looked upwards to see the prototype. Preliminary testing was conducted over a period of three days with the small prototype being placed on top of the coffee machine for each day.

Upon studying more than 20 visitors over three days, some patterns emerged. When more than one person was present to get a coffee, the person directly in front of the machine generally glanced at the prototype and continued getting their coffee and ignored the prototype. When a single person was alone and getting a coffee, it was observed that they typically first peered behind the prototype to look at the servo motor and then, from what we could determine through visual observation alone, approximately 4 out of 20 visitors visibly stood up straighter and breathed into their stomachs in time with the machine. On several occasions, groups of people contemplated the device together and tried to emulate the breathing rate. Two short one minute interviews of people who had used the coffee machine and then gone back to their offices revealed that they did had not noticed the prototype at all.

From this initial investigation, it can be seen that much more research can be done. In our future work, we are primarily interested to learn about the difference between the first prototype (a subtle static device) versus the second prototype (an interactive, responsive device) and how the effects of experiences either prototype carries into the office worker’s day (or not).

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PAPER 2

DESIGNING FOR MEANINGFULNESS: A CASE STUDY OF A PREGNANCY WEARABLE FOR MEN

Carpenter, V. J. & Overholt, D.

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Designing For Meaningfulness: A Case Study Of A Pregnancy Wearable For Men

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Abstract
In this paper, we describe a case study of Fibo – a pregnancy wearable for men (and non-pregnant partners) which allows a partner to feel the movements of their unborn child via a wearable jewellery device. Fibo, in its current state, is a jewellery device housing four pearls which are attached to a servo motor simulating a fetus' movement. We explore other pregnancy devices in related works. The insights gained from early prototyping with Fibo demonstrate a need to design for meaningfulness and we present this as a future work – the need to enable meaningful experiences through thoughtful device design.

Author Keywords
Meaningfulness; Smart Products; Jewellery Devices; Digital Jewellery; Wearables; Craft; Rapid Prototyping.

ACM Classification Keywords
H.5.2. User Interfaces: Haptic I/O; Prototyping; Input devices and strategies; Emerging Interfaces.

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Meaningful jewellery has long been a part of cultural and personal interactions. Jewellery shapes how we relate to each other and how we share memories and experiences, as explored extensively by Ahde-Deal [3]. Sometimes jewellery can ignite a conversation, as with many of the pieces in Ahde-Deal's study on heirloom

Other Pregnancy Wearables for Men:

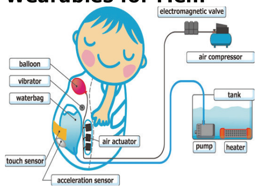

Figure 1: "Mommy Tummy" from Kosaka Laboratory

Figure 2: MammiBelli from SIAT

jewellery, and it can also be "intimate and purposeful" as described by Wright [22].

Wearables, on the other hand, are often technology focused, small computers we wear to notify us of digital happenings [20]. According to one current source, Vandrico's wearables database [19], there are 448 wearable devices currently available on the market, and "watch and wristband shipments will reach a combined total of 100 million shipments in 2016" [8].

Many recent explorations into the combination of technology and jewellery have provided insights into everything from handicraft and material properties [16] to future sustainability questions [17], to aspects of experience and embodiment [12]. Because both wearables and jewellery are worn on the body, they are especially prone to examination about how people interact with the pieces [5, 16, 20, 22], including how the pieces contribute to a person's identity, and what the bodily engagement [12] consists of.

With the flood of new devices, and increasingly, wrist worn, screen-based devices [20], we would like to explore tactile interactions which trigger emotional responses, and facilitate the "dialogical approach" as described by Wright [22], where the design or production of a thing is "never finalized since the experience of it is always completed in dialog".

Furthermore, one of our ambitions is to allow for nearly implicit use of the device, as defined by Kranz et al. [11]: "Implicit use, in contrast, means the user concentrates on his or her prime goal or targeted activity; tool use is intended, the user isn't actually aware of the interaction with the computer system".

Introducing Fibo and designing for meaningfulness

Fibo was a student project developed in a "Wearable Technologies" course in a jewellery design program. Fibo is a pregnancy wearable for non-pregnant partners, allowing them to feel the movements of a fetus. Fibo is explained in detail later in this work.

Through our work with Fibo, and as a reflection of the increasing number of wearables and devices being introduced to market, we have become increasingly focused on *why* a device is being introduced. Beyond producing metrics about, for example, the number of steps we take, or how much water we drink, what is the experience we gain from using these devices; what do these devices enable us to do? We introduce this as *designing for meaningfulness* which will be researched in future works, and is introduced here as a result of our experiences with, and insight gained from, working with Fibo.

In this case study of designing for meaningfulness, we analyze Fibo which a) aims to be a wrist-worn wearable jewellery device – combining jewellery and technology in an elegant, functional way while providing an implicit use scenario, and b) hopes to spark a discussion about how we can design for meaningfulness both in terms of interaction between user and device, and between people.

Fibo, as a work in progress, explores the semi-uncharted territory of pregnancy devices for partners, *linking* the partner to a fetus. As Jung et al. [6] explain: "The meaning of an object can only be ascertained by linking it with something of value, and something of value can gain meaning by being linked to something

Prototyping Fibo:

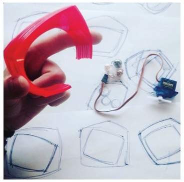

Figure 3: The first 3D Print with servo motor and pearls.

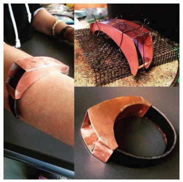

Figure 4: Materials selection process for the bracelet.

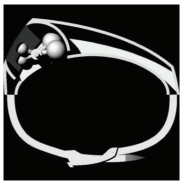

Figure 5: Render of final prototype with pearls mounted inside the bracelet.

else of value. What really makes the difference is the nature of the linkage". In this work, we explore three linkages which we've derived from our experiences with Fibo: identity, enabling stories, and designing for subtlety [13].

As interaction designers, we can design linkages which allow for meaningfulness as per Jung et al [6]. In Fibo, these linkages can be seen as qualities such as:

1. Identity – the partner who is viscerally [18] experiencing the movements of a fetus;
2. Enabling stories – the daily stories between mother and partner and those stories to friends, and family throughout and after the pregnancy; (again, the dialogical approach as per Wright [22]);
3. Designing for subtlety [13] the creation of a non-glanceable device, and instead one which enables tactile, passive, and surprise interaction [16].

Given time, we expect to find more - however we begin with these three as important aspects.

Related Works

When discussing digital jewellery [22], the focus is often on the relationship of the jewellery to the body and extending from that, aspects of emotional bonds, memories or heirlooms [3]. Wright, Wallace and McCarthy explain that their goal is to make objects that have a meaningful place in people's lives. They believe that jewellery instead of wearable is an important context to make things which have an aesthetic context [22].

MammiBelli [7] is a wearable device for pregnant women which monitors kicks and displays these movements on a LCD display. [Figure 2]. *Nuwa* is a system for both mothers and their partners to share the pregnancy experience [24] via a mobile phone app and a fitness tracker. *Smart Maternity Clothes* [9] uses an LED ring, located under the mother's shirt, but visible through the shirt, to demonstrate the movement of the baby and provide movement data. *MommyTummy* is a pregnancy experience system simulating fetal movement [10] using a variety of sensors and actuators in a wearable jacket. [Figure 1]

Two projects exist for the sake of advertising or exploration, and these are the "3 Pregnant Dads" who each wore a 15kg pregnancy suit to emulate the last stages of pregnancy for one month [1]. And in the advertising campaign for Huggies, a set of pregnancy belts were created, one worn by the mother and one by the partner, feeling the baby's movements [2]. While these examples explore ways of monitoring pregnancy, only the "3 Pregnant Dads" and Huggies examples begin to touch upon exploring embodied experience for the *partner*, which is what we are interested in with Fibo. A related product is BloomLife [15], a patch for expectant mothers to wear to monitor the kicks or movements the fetus has. Fibo, not yet finalized, is based upon the sensor data which would come from a device such as BloomLife.

Fibo: Concept

Fibo is a pregnancy wearable for partners of expectant mothers. Based on receiving real-time data from a sensor detecting fetal movements (such as in the product BloomLife), Fibo is a way for the *partner* to experience and relate to, the baby's movements as they happen. Fibo has been designed as a rental

The final prototypes:

Figure 6: The final prototype.

Figure 7: Close up of Fibo on wrist.

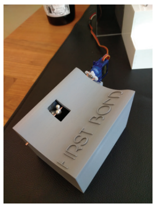

Figure 8: Early prototype for feeling movement of the metal balls against the wrist.

device, being rented for use during the third trimester of a pregnancy.

A band containing four small pearls of different sizes [Figure 5] is worn on the wrist, and when the baby kicks, pushes, or has hiccups, the partner can feel these movements as presses, hits, or prodding against the skin. In this way, the partner and mother of the child can share the physical experience of the baby's movements from a distance (while the partner is at work) and can establish a deeper emotional bond from the shared experience. The aesthetic choices of the jewellery designers is an interesting discussion, however, due to the size limit of this work, it will not be introduced now and may be presented in future works.

Fibo explores the tactile feedback possibilities of a device: instead of using lights or sound as indicators, the team focused their efforts on a design for communicating this intimate moment in a visceral, tangible way [18]. This tangible experience recalls both bodily engagement [12] where the body acts or is acted upon and "adds a dimension of surprise, 'secrecy' and ambiguity" due to the lack of visual feedback on the wrist band [16].

The students conducted user studies using early mockups, and interviewed 10 pregnant or recently pregnant couples. The outcome of these interviews was that the mothers wanted to share the moments, and the partners were happy to be more involved, and did were excited to wear the jewellery object. They could try out the physical sensation via an early prototype. [Figure 8]. The first prototype for Fibo began as a cloth bracelet wrapped around the electronic building blocks containing a haptic vibration motor and was quickly developed using 3D printing [Figure 3] and metal casting for the final prototype which consists of a leather band, titanium casing, and miniature servo motor turning four metal balls. [Figures 4, 5, 8].

Future Work

Fibo will embark on an extensive user evaluation as its next activity, examining interaction and experience as well as hardware choices and regulatory considerations and how to best communicate with a mother device such as BloomLife. Other "mother" products are also being researched as possibilities.

Fibo still has a long way to go before becoming an actual product on the market, including considerations of the medical and ethical implications of the device, however, the process of creating and analyzing Fibo has led to many important discussions around the design for meaningfulness and will hopefully act as a starting point for debate and further exploration around this subject.

Conclusion

Fibo is a work-in-progress, a functional hardware prototype which demonstrates how a pregnancy wearable for partners could be a piece of digital jewellery. Fibo uses hypothetical data from a 'mother device' to emulate a fetus' movement in real time via pearls built into a wrist worn device. This work-in-progress serves to both illustrate the possibilities of digital jewellery and asks: how do we design for meaningfulness? How do we ensure that the new device we are creating goes beyond tracking us and instead, focuses on adding value into our lives and our relationships with our devices, and most importantly, with others?

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PAPER 3

MUSICFABRIK: A PLAYABLE, PORTABLE SPEAKER

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MusicFabrik: A Playable, Portable Speaker

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Abstract
In this work-in-progress we introduce our prototype, a portable speaker augmented to be used as an electronic music sketchpad which allows musicians to play, record and compose multi-track music on the fly. We developed the MusicFabrik cover for the portable speaker, a playable textile cover which, although in functional sketch stage now, shows promise of becoming a useful tool for impromptu loop creation and collaborative music playing. We present our initial user encounters of the sketch. See video: https://youtu.be/pe2QaYv1Imo.

Author Keywords
Musical Sketchpad; New Interfaces for Musical Expression; Meaningful Interaction with Smart Devices; Augmented Portable Speaker; Sound and Music Computing; Musical Interaction.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
In this work in progress, the aim is to explore how we can take a relatively new everyday object, the portable speaker and augment its functionality to include an electronic music sketchpad, allowing anyone musically

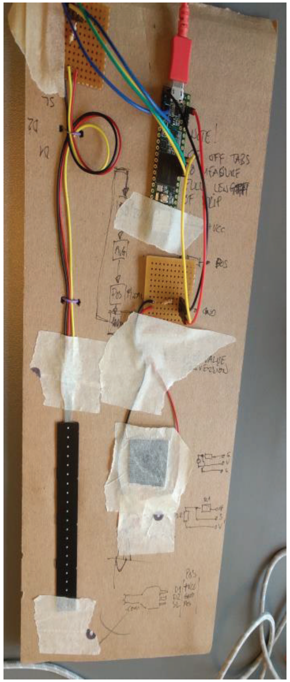

Figure 1 – The first cardboard exploration of pressure sensors and interaction. Image stretched for zoom.

inclined to play, record and compose multi-track music without the need for a computer. It emerges from a curiosity around bringing together two domains: the portable speaker, now nearly ubiquitous in homes, and instruments/music production tools providing the ability to express oneself by creating music. We look to refashion the passive consumption of recorded music into a more interactive experience by changing the role of portable speakers.

For the sake of this work, we are looking to musicians who are interested in creating loops of music, recording these, and even playing collaboratively, on a whim and we target the portable loudspeaker as a platform for this musical sketchpad due to its potential for marketability.

Method

We utilize a research through design method [1] wherein we refer to our early mockup of a functional system as a sketch [2], and gain insight from both the process of developing the sketch and the interactions with users.

Related Works

Electronic music sketch pads exist in many different forms already in the world today such as the KaossPad by Korg[1]. We describe how certain elements of such sketch pads inspire our design in this work. However, to the best of our knowledge there is nothing commercially available combining a portable speaker with such sketchpad concepts (at the time of writing).

One concept which we have been inspired by is the use of hexagonal grid keyboard layouts for musical notes. The hexagonal grid affords the user three degrees of close relationships between directly adjacent notes. Commercially available examples include Snyderphonics Instruments[2], C-Thru Music[3], Starr Labs[4], and Cortex Design[5], some of which are based on historical examples (accordions have been built since the 19th century using various isomorphic keyboards).

We found this interesting for our design, as it positions discrete notes on the hexagonal grid in such a way as to allow musical constructs (chords, intervals, melodies, etc.) to take on the same shape regardless of the tone. This musical isomorphism has been shown to have advantages in learning [5], composition [6] and performance [3].

More straightforward interaction designs for musical sketchpads include products such as Teenage Engineering's OP1[6] or ROLI's blocks[7]. These tend to use looping as the interaction style; a wide array of both hardware and software looping stations exist today. Academic research into this areas includes projects such as the Musical Navigatrics [7], or the reacTable [4]. However, as with the commercially available products, these projects tend to primarily be

1 http://www.korg.com/us/products/dj/kaoss_pad_quad/

2 https://snyderphonics.com/

3 http://c-thru-music.com/

4 http://www.starrlabs.com/

5 https://www.cortex-design.com

6 https://www.teenageengineering.com/products/op-1

7 https://roli.com/

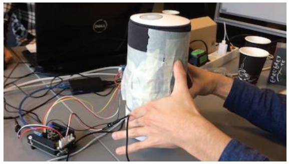

Figure 2: First on-speaker explorations of what it might be like to play on the speaker itself.

Figure 3: Connecting the speaker to the BegalBone Black and a Bela and then to a keyboard.

controllers, and do not combine a high-quality speaker into the design of the interface itself.

Interface

To keep the look and feel of the speaker intact, we explored having fabric buttons as part of the (removable) cover of the speaker. We developed an interface which can function either while attached or detached from the speaker. We used Eeontex fabric[8] connected to individual analog inputs on a PJRC Teensy along with Interlink Force Sensitive Linear Potentiometer sensors to determine the capabilities of the Eeontex fabric. Both the button and the fader are force sensitive and have proved to be precise in reaction to interaction.

The hexagonal grid as a keyboard layout

The aim of the uncommon layout is to simplify the learning process and improve the playing experience. After examining the pros and cons of the several different keyboards' layouts, we decided to introduce in our project a Wicki-Hayden based keyboard. The keyboard is composed of several hexagons and its layout is isomorphic since any given musical pattern (scale, chord etc.) has the same shape independently of the starting pitch. This permits having a certain conformity between the hand's position on the keys and the sound that this particular position produces.

The keyboard should be playable both while attached to speaker or removed, so three different layouts were created. Two of these were based on the Wicki-Hayden layout but modified. One of these were only slightly modified, while the other was a hybrid between a Wicki-Hayden layout and a matrix of 4 by 5 square pads where each pad represents a chord. The third layout was based on a modified version of the classic piano layout.

Hardware

To develop a functional prototype, we used a BeagleBone Black (low-power, single-board computer) connected to a Bela[9] expansion board. After connecting the line-out of the Bela to the line-in on our speaker, we connected a MPR121-based breakout board and capacitive sensors to the Bela and using a C++ sketch provided by the developers of Bela we were able to produce sounds when the capacitive sensors were activated. The pitch of the sound depended on which sensor was activated. We then attached the sensors to the speaker using tape to explore what on-speaker interaction might be like.

Software

To further explore how we might play different samples dependent on sensor activation, we looked into the SoundFont synthesis specification[10], which allows audio samples and sound effect parameters to be stored in a single file allowing a software synthesizer to produce a high-quality instrument sound. There are many royalty-free SoundFont files available online with high-quality instrument soundbanks. We used the open-source TinySoundFont (TSF) C/C++ library[11] to load SF2

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8 https://www.sparkfun.com/products/14110

9 https://github.com/BelaPlatform/Bela/blob/master/examples/06-Sensors/capacitive-touch/render.cpp

10 https://en.wikipedia.org/wiki/SoundFont & http://freepats.zenvoid.org/sf2/sfspec24.pdf

11 https://github.com/schellingb/TinySoundFont

The keyboard layout on the speaker cover:

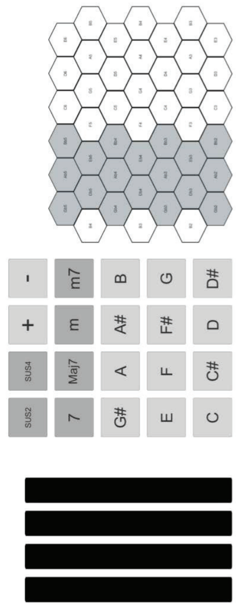

Figure 4 – The Wicki-Hayden layout combined with a matrix of chords and controls.

SoundFont files to memory and synthesize the final audio output using the BeagleBone/Bela.

Initial User Encounters

To gain insights into how musicians might use the speaker, we took the sketch to the three users. We used the protocol by Wu and Bryan-Kinns [8] as they were working with a new musical interface and designed their procedure to allow for experimentation and exploration of the interface through a three session setup: introduction, interaction with a prototype and interview. Our participants were people with at least some experience with creating electronic music and who had used a loop device/feature before.

The main purpose of the user encounters was to gather feedback on specific fundamental elements of the sketch:

- Determine usability of the looping function: How was it to use this for looping music?
- Will users prefer to play music directly on the speaker (on the MusicFabrik cover), or will they prefer to take the cover off?
- Which use case scenarios do the participants see?

The three participants found the looping function both fun and useful. One participant suggested that the keys could be placed in two different sides of the speaker to be able to play with both hands. Another participant enjoyed using the sensors on the speaker for playing drum sounds because he found the touch sensor of the speaker more responsive. When asked whether they preferred to play directly on the speaker or take the MusicFabrik cover off and place it on the table; one participant preferred to place the cover on the table because it felt more natural, like a traditional keyboard, the two other participants stated that it depends on the situation. If a flat and sturdy surface is available they would place the cover on that, however, if not, they would prefer to play directly on the speaker. One participant suggested a use case for playing directly on the speaker could be taking the speaker with the cover on it to the park and sitting in the grass while working on new music ideas.

Participants agreed the hybrid keyboard with both pads and a small version of the Wicki-Hayden would be the easiest to play on the keyboard by people with little musical experience. Two participants preferred the piano-like keyboard as a controller when unwrapped, while the third found the hybrid one to be a better solution for them. The two participants with less experience in playing piano found the layout of the Wicki-Hayden keyboard interesting, and expressed their interest in playing it without knowing the actual advantages of this layout.

Conclusion

We presented an augmented portable speaker designed to include an interactive electronic music sketchpad, allowing anyone musically inclined to play, record and compose multi-track music without the need for a computer. We explored our sketch with three users who provided feedback on the interactive looping functionality, the concept of a playable MusicFabrik cover wherein the portable speaker's cover is playable (on or off the device), and the concept of collaborative play. We found that each of these areas is interesting to continue working with in future research.

Future Work

The results of the user test show promise for continued development of a custom MIDI controller attached to the speaker. Specifically the modified version of the Wicki-Hayden layout concept with an additional square pad area for playing preset chords and drum sounds received high marks among the testers. Our next software and hardware milestones include making the looper more robust and optimizing the SoundFont synthesizer library in order to avoid buffer underruns. In order to fit the sound processing hardware inside the speaker, it would useful to research the feasibility of combining the recently released Pocket Beagle[12] with a smaller custom version of the Bela expansion board. A future prototype would also incorporate all the hardware into a removable cover for the speaker. Further development on the hardware including PCB design is required for this. We will explore these options in our next prototype iteration.

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[12] https://beagleboard.org/pocket

PAPER 4

SKETCHYTUNA: EXPLORING A DESIGN FOR SCREENLESS CREATIVITY

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SKETCHYTUNA: EXPLORING A DESIGN FOR SCREENLESS CREATIVITY

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1. ABSTRACT

In this paper we explore the idea of transforming a portable speaker into an interactive music sketch pad using low and high fidelity prototyping. We present research into the current state of the art of musical sketch pads and specify the requirements for a new concept based on pressure-sensitive conductive fabric. We developed a virtual prototype and subjected it to user testing. Results from the user test led to the design and implementation of a high fidelity prototype based on a single-board computer with an additional audio interface communicating with a custom embedded MIDI controller. A real-time, loop-based musical software platform was developed as part of the high fidelity prototype. Finally, user test results are presented and discussed.

2. INTRODUCTION

Many digital music interfaces have been made in the last decades, ranging from reconstructions of ancient instruments [1] to futuristic devices [2]. Where most musical interface designs are based on a set of musical and sonic requirements, this project is a research collaboration with a speaker manufacturer and therefore has an existing speaker design as the starting point of the concept. The aim is to enhance the speaker with musical functionality while maintaining the portable aspect.

We have chosen to focus on already skilled musicians and people with some experience on looping devices or portable synthesizers. The speaker at hand has a cylindrical form and a textile cover on the body. We opted for a detachable cover that can be played by taking it off and laying it on a flat surface. We proposed different layouts and tested them on a touchscreen before making the physical version. The final hardware layout works with our own sketch pad software that allows for looping [3], playing chords, arpeggios and more. The main sketch pad software runs on a low-latency single-board computer, the BeagleBone Black, [4] connected to the Bela audio interface cape [5]. User input is registered on the sketch pad controller containing pressure-sensitive fabric attached to a circuit board, which is connected to a Teensy microcontroller [6]. Through this report we will investigate how a portable speaker without interactive musical functionality can become a music creation tool.

3. BACKGROUND

The inspiration for this project emerged from two distinct fields of experimentation; the use of loudspeakers as instruments and the use of computers for music creation.

Making the loudspeaker musically interactive would in essence transform it into a musical instrument. However, the concepts of using loudspeakers as instruments is not new. Experiments using deliberate audio feedback began soon after the introduction of the electric guitar and amplifier [7]. Deliberate audio feedback is created by placing an electric guitar in close proximity to the amplifier's speaker. The resulting effect can be heard in songs such as "Foxy Lady" by Jimi Hendrix [8] and "I Feel Fine" by The Beatles [9].

The Acousmonium project by Francois Bayle is another example of loudspeakers being used as musical instruments [10]. For a performance of Acousmonium a series of different loudspeakers were distributed in a fashion similar to how a symphonic orchestra is arranged on a stage. Different loudspeakers presented different frequency response characteristics, which was exploited by the performer to add different "voices" to the orchestra.

Some multi-purpose digital devices are sold as musical sketch pads, in the sense that the user is able to quickly pick up the device and save fleeting musical ideas for later use. Two popular examples of such devices include the OP-1 by Teenage Engineering [11] and the Organelle by Critter and Guitari [12]. The Noise app by Roli is marketed as "A handheld music studio" [13]. Noise is a free application that allow the user to quickly record a set of loops using pre-configured instruments. These loops can then be arranged to form a complete piece of music.

There has also been considerable academic interest in prototyping musical interfaces and controllers [14], some of which focus on non-visual interaction. In the paper by Cila et. al. [15], it is argued that visual feedback to the user in some cases may be replaced by haptic or auditory feedback. This view is also supported by Tsaknaki et. al. [16] where the design of a screenless digital notepad was explored.

4. REQUIREMENTS FOR THE SKETCH PAD

The musical sketch pad we designed can be seen as a toolbox for the musician. It is portable with a selected set of tools used to sketch out temporary ideas. It includes the basic musical functionality required to play and compose music. In addition to the internal sample playback, microphones or other audio sources can be connected to the sketch pad through the audio input.

If the user wants to play without connecting an instrument that outputs sound, the sketch pad controller or external MIDI instruments are used. The controller as designed allows the user to play chords, arpeggios and control the device as a whole. A looper is implemented so the user can build beats and melodies on top of each other. This is commonly called *live looping*, as it refers to the composition of a piece of music in real-time [17]. All the features work in tandem with the looper. Audio input, chords, arpeggios, melody and percussive beats can be looped on multiple tracks, and if mistakes are made, the track can be cleared and re-recorded.

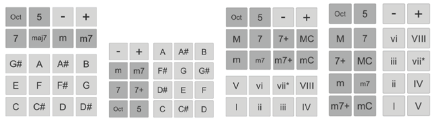
5. DESIGN CONSIDERATIONS

5.1 Layout testing

To utilize the available size of the speaker surface, various layouts were prototyped on a touchscreen laptop running Unity [18]. Four grid-based virtual pads were made as seen in figure 1, and subsequent tests focused on 4×5 square pads being used to play chords. The ability to play chords by pressing a single pad lets the user compose quickly on the fly. This allows the user to play chords and a melody on another pad at the same time. The choice of 4×5 pads was due to hardware limitations and this led to having a single octave of 12 tones and 8 additional pads, where 2 of them are used for changing the octave. By holding down one of the remaining 6 buttons, the tone pressed changes to that chord type. A major chord was used as the default.

As the chord repertoire of skilled musicians stretches far beyond 6 types, another layout was proposed to make room for more chord types. By using roman numerals to choose the chord number in the major scale instead of the 12 semitones of an octave, the number of tone buttons decreased by a third. This gave an additional 4 pads for chord types, but limited the chords to the major scale, which is well suited for mainstream pop songs.

Each of the layouts has two variations. One with the chord types on the top seen in figures 1a and 1c and one



(a) (b) (c) (d)

Figure 1: Chord surface layouts. Semitone layout with chord types on top (a) and side (b) and Roman numeral progression with numbers on top (c) and side (d).

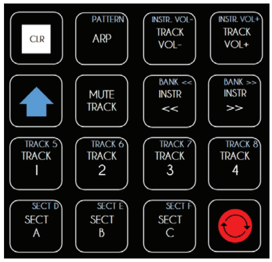


Figure 2: The control surface layout.

to the side seen in figure 1b and 1d. Users found having chord types on the side easier to play with one hand. The roman numeral layout required additional buttons to change the tonic from the default C major scale. This was solved by holding down a "key change" button on a melody grid and pressing a tone signifying the desired key.

Skilled musicians that tested the roman numeral layout noted that they were not familiar with the system which made it hard to play along to a song, if the chords were looked up on the internet or from sheet music. One non-skilled user felt it was easier to play music with the roman numeral layout, but as the target audience is skilled musicians, we diverted back to the 12 semitone octave and chose the variation with the chord types on the side.

5.2 Control surface

The looper control surface seen in figure 2 can switch *tracks*, which are audio clips stored in memory, and *sections*, which are song structure elements. For the left hand-side control surface, we used a 4×4 key grid layout. On the physical device there is a single LED above each of the keys, making it possible to reveal the state of the looper at any given time.

The two keys for managing loop tracks (REC and CLR) are located in two opposite corners to minimize the risk of accidentally pressing the CLR button and losing data while rushing to press an adjacent key. Pressing the REC key for the first time puts the looper in listening mode, clearly indicating this by putting the LED above it in a blinking state. Either playing a note or pressing the REC key for a second time will start the audio clip recording.

Pressing the REC key for a final, third time while its LED is constantly on (i.e. while recording) will store the

Figure 3: A mock up of the sketch pad controller on the speaker.

recorded audio clip in memory and immediately start looping it. The first recorded clip (track) determines the musical bar length. No metronome or tap tempo is required, giving users the ability to perform in any time signature.

There are three function toggle keys on our control button layout. The blue Shift key brings another dimension to the whole layout, allowing us to add functionality at the cost of an extra action. Shift functions are not as accessible as the primary functions and are therefore reserved for less time-critical, yet required operations, such as changing the instrument bank or switching over to a less frequently used instrument track or section. It acts similarly to the Shift key of mobile on-screen keyboards as it gets released after a single subsequent keystroke.

The Mute Track key will immediately mute the currently selected track. Its behaviour differs from clearing a track in that it instantly mutes it, whereas the CLR key would cut playback at the end of the current clip to allow stopping multiple tracks precisely at the end of the bar.

Finally, the ARP key toggles between chord and arpeggio modes, defining the way harmony is played on the right hand pads. The arpeggio and chord functions are described in more detail in section 7. A mockup of the layout as it would look on the speaker can be seen in figure 3.

6. SKETCH PAD CONTROLLER

In order to test the required features and research the optimal manufacturing techniques for fabric-based MIDI controllers, a prototype embedded device had to be designed and constructed. This involved a design stage as well as a hardware and software development stage.

6.1 Design

The hardware design is based on the user tests conducted using the virtual keyboard layouts developed in Unity. However, the layouts were modified slightly, so they could be manufactured with the tools available in-house at Aalborg University Copenhagen. This resulted in three separate rigid PCBs; each dedicated to a separate function for easy modification. As we can see in figure 4, the first PCB from the left contains the looper controls and LED indicators. The middle PCB is a motherboard for the microcontroller and the haptic motor controller. The rightmost PCB contains the keyboard for triggering musical notes and buttons for selecting the chord type. For an overview of the hardware connections see figure 5.

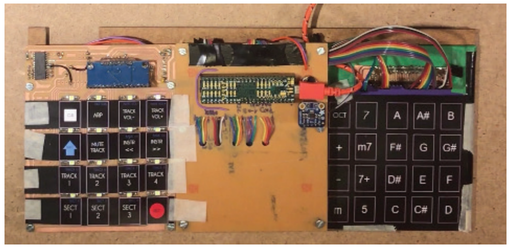


Figure 4: The sketch pad controller hardware prototype.

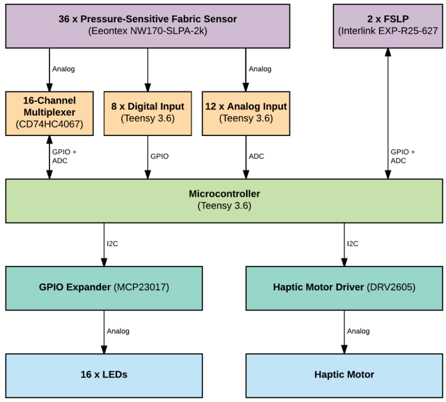


Figure 5: Hardware connection diagram.

The main difference in our design versus most other current MIDI controllers is that the final version of the controller must be physically flexible in order to be wrapped around the cylindrical speaker.

Since Bela has support for MIDI input and output via USB, it made sense to base the controller design on USB MIDI as both data and power transmission could be accomplished over a single cable. Among all of the microcontrollers available, not many have built-in support for USB MIDI making the top candidates the Teensy family of development boards by PJRC [6]. We chose to use the most recent board, the Teensy 3.6 which contains a 32 bit 180 MHz ARM Cortex-M4 processor [6] and has a large number of analog inputs.

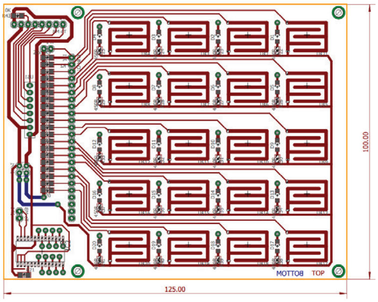


Figure 6: Sketch pad control surface PCB layout.

6.2 Hardware

Due to the complexity of the interconnections between the components, the cover prototype hardware required a custom PCB layout in order to provide us with a stable platform that would stand up to being interacted with as a musical interface.

Autodesk Eagle [19] was used to create the schematics and PCB layouts for three separate single-sided PCBs, an example of which can be seen in 6. Due to the prohibitive cost of manufacturing flexible PCBs, a Bantam Tools PCB milling machine [20] was used to manufacture the prototype boards.

The sensors used for the controller buttons are based on Eeontex NW170-SLPA-2k [21], which is a pressure-sensitive conductive fabric. When pressure is applied to the fabric its electrical resistance decreases, which is a condition that we can measure and use as a control input value.

In order to utilize the Eeontex fabric as a sensor, a technique commonly used to construct membrane switches was employed. By creating PCB traces that are interleaved but not touching, an area is created where electrical contact can be made when a membrane switch is pressed or in our case, when a pressure-sensitive fabric is pressed.

Since the Eeontex fabric changes electrical resistance when compressed, the most practical way to measure the applied pressure is to consider the fabric one half of a voltage divider and connect it to the development boards 3.3V power supply. By using a fixed resistor with a value of 3.3kΩ connected to ground for the other half of the divider, the varying resistance of the fabric can be measured as a voltage using an analog input on the Teensy development board. The output voltage seen at the ADC input can be calculated using the voltage divider formula in equation 1.

$$V_{out} = V_{in} \times \frac{R2}{R1 + R2} \tag{1}$$

Instead of finding the output voltage, it is more useful to find the resistance value maximum and minimum when the fabric is not pressed and with the maximum expected finger pressure applied. By measuring the output voltage in these two cases, we can rearrange equation 1 to calculate the value of R1. Measurements obtained with a standard laboratory voltmeter indicate an output voltage of approximately 0.2V when not pressed and around 3V with maximum pressure. This gives us range of resistance values for a 1.2 $\times$ 1.2 cm square of Eeontex material spanning from approximately 50kΩ to 0.33kΩ.

For this version of the prototype, the pressure-sensitive fabric is directly attached to the PCB using double-sided tape with a cutout in the middle to allow for electrical contact. This method is very simple and performs sufficiently for prototype testing, but after multiple presses in the same area the fabric has a tendency to get stuck and cause false triggering.

The other main active components in the design are the DRV2605 haptic motor driver, the MCP23017 I2C GPIO expander and the CD74HC4067 multiplexer. The DRV2605 and the haptic motor are located on the motherboard, and generate haptic feedback when a button is pressed. Since the fabric has limited tactile feedback, we anticipated that synthetic tactile feedback when a button press is registered would provide the user with a more natural interaction with the device. Although the effect with the current motor is very subtle, it provides a useful response when the user interacts with the interface.

The MCP23017 GPIO expander is used to expand the system with 16 additional digital pins that are connected to LEDs on the looper control board. Each LED can therefore be controlled individually without giving up pins on the microcontroller. The expander is controlled via I2C, which allows it to be placed close to the LEDs, since it only needs two data wires back to the Teensy development board.

Finally, the CD74HC4067 is used to switch the signal from the 16 buttons on the looper control board and feed them into a single analog input on the Teensy. In this way, the pressure values of multiple buttons can be measured using only one analog input. There is of course a tradeoff in this situation as the sampling rate for these buttons will be divided by 16, i.e. the amount of sensors that must be measured. However, as we shall see in the following chapter, the latency caused by the multiplexer switching is negligible.

6.3 Software

The software for the user interface is based on a superloop architecture [22], which after the initial setup procedure has completed, keeps iterating indefinitely as can be seen in figure 7.

Within the superloop, the software follows a predefined path starting from the top to the bottom testing for a specific condition for each input type. If a button press is registered, a corresponding action is performed, sending out a MIDI message and triggering haptic feedback. If a valid MIDI input from another device is registered, in our case from the Bela, although it could be from any device with USB MIDI host capabilities, the LED indicators are set accordingly. If no input is registered, the program keeps looping through the code indefinitely. In order to simplify the communication between the controller and the Bela, each button and LED indicator was mapped to a specific MIDI message. Table 1 shows the MIDI mapping within the controller.

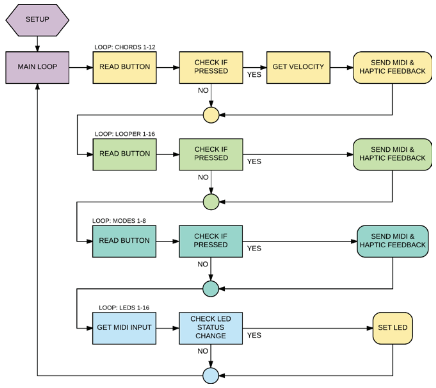


Figure 7: Sketch pad controller software flowchart.

CONTROLS	NOTE	VELOCITY	CHANNEL	I/O
Looper 1-16	0-15	ON: 127; OFF: 0	1	Output
Mode 1-8	20-27	ON: 127; OFF: 0	1	Output
Chord 1-12	30-41	ON: 127; OFF: 0	1	Output
LED 1-16	0-15	ON: 127; OFF: 0; BLINK: 64	ANY	Input

Table 1: MIDI implementation chart for sketch pad controller and software.

The same mapping strategy was employed in the sketch pad software in order enable communication between the sketch pad controller and software.

The software relies on a range of classes to communicate with the various input and output devices in the system (see system diagram in hardware section). This keeps the software architecture flexible in order to accommodate future hardware changes. The connection between the classes can be seen in figure 8.

To generate velocity values for the MIDI Note On messages, the software attempts to find the average velocity of the pressure value curve. The result is converted to a value between 0 and 127 to fit with the velocity value used in a standard MIDI Note On message. The average velocity can be determined using equation 2:

$$AverageVelocity = \frac{Y2 - Y1}{X2 - X1} \tag{2}$$

Since we are comparing subsequent samples with a fixed

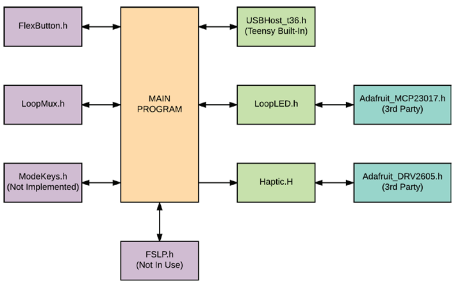


Figure 8: Sketch pad controller class diagram

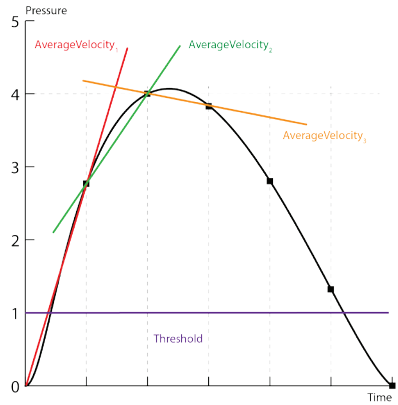


Figure 9: Arbitrary average velocities at sequential sample points.

time interval, we know that the difference between X2 and X1 is always 1 in an arbitrary time scale based on the chosen sampling rate and we can therefore simplify as seen in equation 3:

$$AverageVelocity = \frac{Y2 - Y1}{1} = Y2 - Y1 \tag{3}$$

As we can see in figure 9, the average velocity is shown for 3 different samples. The values for $AverageVelocity_2$ is used to calculate a velocity value for the MIDI Note On message, since it is the first measurement to have a pressure value higher than the threshold. All subsequent samples are then ignored until the pressure value has fallen below the threshold; after which the process is be repeated. While the pressure is above the threshold, the measurements can be used to calculate a value for MIDI Aftertouch messages, which in turn can be mapped to modulate the sound timbre or other relevant controls.

We use a 58 kHz sample rate with a 4 sample average resulting in a sample every 17.24μs measured on a Teensy LC. Since we are sampling a total of 36 buttons on 13 analog inputs (using a 16 input multiplexer for the looper control buttons) and 8 digital inputs, each buttons should be sampled once every 36 * 17.24μs, equal to 620.64μs or 0.62ms. Adding to this, switching inputs on the multiplexer will take around 0.71μs * 4 pins * = 2.84μs for each input using the normal digital output functions on the Teensy [6]. This amounts to 45.44μs or 0.04544ms in addition to the previous 0.62ms giving us a final value of 0.67ms between samples of each input.

This is not taking into account other processes such as USB MIDI processing, setting LED indicators and such.

7. SKETCH PAD SOFTWARE

The sketchpad looper (figure 10) was written in C++ 11.

7.1 Looping audio tracks

The process of recording the first loop is shown in figure 11. Any subsequently recorded tracks are added to the

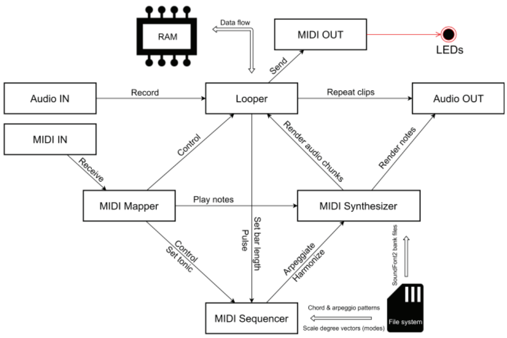


Figure 10: Looper system architecture.

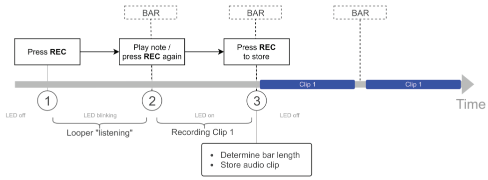


Figure 11: Looper timing: defining the bar length.

mix taking into account two important factors. One is the amount of time that has passed since the start of the current bar, which will be used to shift the new clip in time so that it will be played back in the same relation to the bar line as the original performance. The latter is also referred to as the track offset. If a new track is much longer than the bar length, repeating the clip on each bar would produce unwanted notes, especially in cases where long phrases containing complex chord progressions are involved in the performance. The second factor is the amount of bars that phrases span across, that is determined by rounding the ratio between the amount of time of the new track and the original bar length as depicted in figure 12. The latter would reset only when all tracks from all sections are cleared from memory, effectively deactivating the looper. Manual clearing of the selected track is done by pressing the CLR button.

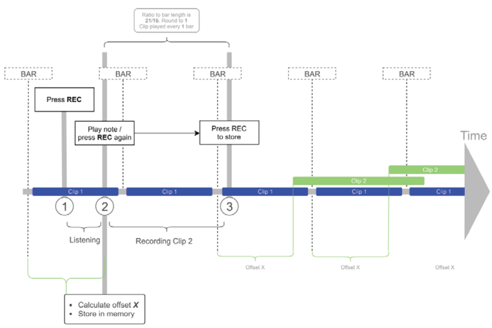


Figure 12: Looper timing: recording a second track.

7.2 Sequencer and MIDI synthesizer

The implementation was largely made possible because of the compatibility between Bela and a single-file library providing an open-source SoundFont 2 synthesizer based on the open Sforzando (SFZ) [23] file format.

Any MIDI device connected to the BeagleBoard is linked to the synthesizer making it possible to hear real recordings of instruments with dynamics control when physically playing notes on the MIDI device.

The mapping of MIDI data being transferred is established in the MIDI Mapper module. Most MIDI piano key devices are inherently supported by it and pass the Note On and Off messages over to the Synthesizer module, but any complex MIDI control surfaces would need to be manually re-mapped in order to enable users to use them for controlling the looper or changing the instrument. The MIDI Mapper is also responsible for interpreting MIDI note-on messages coming from the control surface in which the required action is signified by the pitch value of the message, as seen in table 1 in section 6.

Even though the Sequencer module is a relatively recent addition, it provides a basic technique for scheduling function calls relative in time to the looper cycle. Since the bar size is measured in samples, finding the sample length of a quarter note is done by dividing the window length by four.

One of the requirements for this project is the chord customization pad implying that chords would need to be constructed in one of the many ways possible. Four basic patterns are included in the current setup - major and minor triads with the median moved an octave up, their inversions and a neutral chord composed by two fifth intervals in 2 adjacent octaves. Changing between these is done by pressing the Shift key followed by the ARP key.

Pressing the ARP key without Shift toggled puts the sequencer in arpeggiator mode, breaking up chords in a way that will fit the timing of the looper. The sequencer, like any standard USB MIDI device connected to the Bela, provides the synthesizer module with instructions to play notes in the form of MIDI messages.

8. EVALUATION AND DISCUSSION

The prototype was evaluated with three users. The results of the evaluation were used to determine how the user experience of the prototype could be improved. The user evaluation methodology was modeled after the one used by Wu & Bryan-Kinns [24]. The testing procedure consisted of a three session setup designed to make it possible for the user to explore prototypes and provide feedback of their experience. The four sessions are: 1. introduction, 2. interaction with prototype A, 3. a short interview.

The participants all had some experience in creating electronic music; one of them was very experienced. All three participants regularly use loop features while playing or for inspiration when composing. Furthermore, they all use Ableton Live frequently, a loop based music creation software [25].

The overall impression was that the participants were interested in interacting with the prototype in order to create loop based music. Occasionally technical problems impeded the user experience.

All users found the looping feature intuitive to use and appreciated the functionality of having separate sections. Using an early version of the sketchpad controller firmware, the primary problem mentioned unanimously was the latency of the buttons. The availability of a large array of sounds was generally found stimulating. However, the order of the sounds made it difficult to navigate the available sounds. Navigating the sounds also became an issue when the participants wanted to delete a specific loop, but could not locate the instrument the sound was recorded with. Some users expressed an interest in being able to play single notes instead of chords in order to develop riffs or perform a musical solo along to recorded loops. Octave button was never utilized and the major/minor switch rarely, the arpeggiator button functionality was found non-intuitive. The pressure sensitivity provided by the chord surface was not taken advantage of because participants were more concerned about the music being on time than on the musical expressivity.

Although the sketch pad controller showed potential, a marketable product would require additional development efforts and further user testing. Also, substituting the currently used Bela with the recently announced Bela Mini would make it possible to achieve similar performance in a considerably smaller footprint and should be investigated further [26].

9. CONCLUSION

In this paper have we presented a musical sketch pad prototype. The project started as an exploration of how a portable loudspeaker could be transformed from a passive to an interactive object that enables useful musical expression and creation. Early in the initial idea generation phase we decided to transform the speaker into a musical sketchpad on which the user is able to quickly sketch musical ideas. Initial user testing was conducted using virtual and low-fidelity prototypes of the layout designs. Based on the results, a fully functional high-fidelity prototype containing hardware and software was designed and evaluated.

The sketch pad software was programmed to provide a feature set determined from the initial requirement specification and user evaluation. A final round of user evaluation was conducted using the high-fidelity prototype to evaluate the functionality. Based on the evaluation, we concluded that the prototype has potential for further development.

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PAPER 5

DESIGNING FOR INTERPERSONAL CONNECTIONS IN FUTURE TECHNOLOGIES: AN ANNOTATED PORTFOLIO OF JEWELRY DEVICES

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Designing for interpersonal connections in future technologies: An annotated portfolio of jewelry devices

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Abstract

This work presents 4 design artefacts as an annotated portfolio, exploring how to design for tangible, non-screen jewelry devices which enable personal and interpersonal connections. We posit that these connections are key in furthering people's relationship with technology, beyond the basic functionality and efficiency of many so-called smart products today. To explore these connections, we have chosen to design jewelry devices as most traditionally crafted jewelry does not usually serve a particular functional purpose beyond emotional engagement, such as a wedding ring, an heirloom or a photo locket.

As wearables become more ubiquitous, we look to traditional craft to inform future designs and ask the question of which combination of technology and traditional craft can enable these connections and more meaningful experiences via our devices.

We explore related works in interaction design where traditional craft and technology has been combined and create an annotated portfolio of our designs as an attempt to exemplify qualities which are not typically tacit in the design of smart products.

Through reflection of each of the artefacts, the following four annotations are derived: 1)Desire as a driver of jewelry devices; 2)Engagement beyond useful functionality; 3)The current day novelty and importance of an app-less device and; 4)Using links to achieve deeper connections: people to people, a person to their sense of self, and a person to time (past, present or future).

This work contributes as a key insight, that in a time where 'smart products' are emerging in every domain, interaction designers can utilize traditional craft and the connections described in this work to influence and contribute to the thoughtful and thorough design of these future devices, helping create a future where technology enables richer interpersonal relationships.

Keywords: Product Design, Jewelry Devices, Jewelry, Wearables, Craft, Rapid Prototyping, Emerging Interfaces, Meaningfulness, Smart Products

1 Introduction

In recent years, exploration and creation of jewelry devices, smart jewelry, and uniquely designed wearables has increased its popularity in both interaction design and in commercial, consumer facing products (Golsteijn, Van Den Hoven, Frohlich, & Sellen, 2014; Tsaknaki, Fernaeus, & Jonsson, 2015; Tsaknaki, Fernaeus, Rapp, & Solsona Belenguer, 2017; Wallace, Dearden, & Fisher, 2007). A focus on craft in interaction design has been prominent (Tsaknaki, 2017; Padfield et al, 2018) and this combination of craft, interaction design, and technology helps to shape which products people might use in the future as we begin to adopt more and more smart personal wearables. This work aims to investigate this space, specifically focusing on designing for the personal and interpersonal connections for these future technologies.

Within commercially available wearables, the focus tends towards quantified self as can be seen by the market density of fitness trackers and health based devices (Vandrico, 2018). There are few current products on market which focus on personal (such as Thync, 2018) or interpersonal connections (such as the Hey Bracelet, 2018). Several take on the form of functional jewelry, as presented below in **Related Works**. Research within HCI (Human Computer Interaction) on the other hand, can be seen as promoting a variety of personal and interpersonal interactions such as design for self-development (Zimmerman, 2009), research which warns against technology which *limits* person-to-person connection (Cervantes et al, 2016), research which explores personal connection with the self (Núñez and Loke, 2017) or even interpersonal touch (Marshall and Tenant, 2017; Hobye and Löwgren, 2011). These examples aim to demonstrate the breadth of research within HCI about interpersonal or personal connection. This work aims to explicitly present four values which could be useful in designing for interpersonal or personal connections within future jewelry devices.

While the academic researcher might be familiar with designing for personal or interpersonal connections, there exists an opportunity to inform the design of new, intended-for-market wearable technologies which utilize jewelry design. Within this work, alongside jewelry designers and industry, we explored how we might design future technologies which consider personal and interpersonal connections while creating a traditionally crafted, smart product. From this, four qualities emerged and we propose this work as the beginning of a discourse about what future, on-market wearable technologies can be when they are designed for personal or interpersonal connection.

2 Framing the projects

In this work, four cases are presented: Trace, Mirror, Mirror, Connect and Fibo, all of which result from an 8-week long course in wearables as part of a professional bachelor program for jewelry, technology and business. The students were given a set of design challenges by the author who was leading the hardware development of the jewelry devices. Coming from a position in a product development and engineering company, the author chose these challenges based on a review of recent work within non-screen devices such as Rose's "Enchanted Objects" (Rose, 2014) Uglow's "Internet without screens" (Uglow, 2015) and Wakkary's "Morse Things" (Wakkary et al., 2017) where there is an increasing interest in everyday objects, enchanted by technology, which highlight qualities of subtlety, glance-ability (and non-glance-ability in the case of Morse Things). Further, given the vast array of available on market technology which predominantly utilizes an accelerometer and a screen (fitness or health tracking devices) the students were challenged to think past this parameters, and imagine future technologies which might incorporate the following (these are the challenges):

- No screens – what might an app-less device look like?
- What other than light could be an output?
- How might you use interesting or unusual sensors? (What can humans not (easily) sense?)
- Could it be an heirloom device - or how could it exist as a sustainable solution?

The concept of heirloom devices and sustainable solutions emerged from discussions with the school about what the major challenges might be to people developing future technologies, such as sustainability of devices and avoiding planned obsolescence.

3 Research Through Design & Annotated Portfolios

This work presents 4 cases of jewelry devices which have acted as experiments to help deduce qualities about designing for personal or interpersonal connections. Hobye describes the annotated portfolio as "a way to communicate these qualities to a wider audience within design research" (Hobye, Padfield, & Löwgren, 2013). Gaver, in introducing annotated portfolios, explains: "Design, and research through design, is *generative*. Rather than making statements about *what is*, design is concerned with creating *what might be"* (Gaver, 2012). In this work, we are asking what might be. This is a method wherein design artefacts go through a process of "ideating, iterating, and critiquing potential solutions" (Zimmerman, 2007) and act as exemplars which reframe the problem. We use the jewelry devices produced by the students as vehicles for design research, leading us to reflections about how we might design future wearable technologies using jewelry design as a traditional craft technique incorporated with interactive technology.

Gaver presents annotated portfolios as "a collection of designs" which, when compared, act as "articulations of the issues, values and themes which characterize the relations among the collection" and which "maintain the particularity of individual examples, while articulating the ideas and issues that join and differentiate them" (Gaver & Bowers, 2012; Gaver, 2012). Löwgren describes that "annotations occupy some territory between the particular artifacts and the general theories" (Löwgren, 2013) and that this territory is "non-empty", that it is occupied by "intermediate-level knowledge" which might be *patterns*, *concepts* or *experiential qualities*.

In this work, we utilize the form of an annotated portfolio to highlight the method of research through design wherein we have created early stage prototypes to discover *intermediate-level knowledge* and investigate emergent qualities and potential solution areas. We acknowledge the complexity of research through design (Redström, 2017) and state that this work is open ended. It invites a discussion of qualities designers might consider when designing for interpersonal connections in future technologies, especially within wearables. It reports on the findings which are a result of domain identification, user evaluations, early prototyping and user testing and reflecting on these designs. The ambition of this work is to invite a discourse around the proposed qualities and the challenges provided to the students in the design of these four works.

4 Related Works

4.1 Jewelry and technology

There has been a tremendous amount of work done in exploring traditional craft in HCI and we do not aim to cover it here. Rather we look to a few examples to gain insight into why jewelry has the potential to act as enablers of interpersonal and personal connections.

Tsaknaki et al have done a series of works exploring craft and HCI (Tsaknaki et al., 2015, 2017; Tsaknaki, Fernaeus, & Schaub, 2014; Vallgårda, Boer, Tsaknaki, & Svanaes, 2016). They emphasize the aspect of time, things which last (Tsaknaki & Fernaeus, 2016), and explain that the “imperfections of current technology are used actively as a design resource, rather than a barrier for design”. The concept of something that lasts and design which incorporates flaws, can be clearly seen in jewelry design. Often, wedding rings or photo lockets might be obvious emotional jewelry pieces and Ahde-Deal, in her work on women and jewelry, (Ahde-Deal, 2013) uncovered some unique pieces, such as the ‘alewife pins’ – small dried fish made into pins which are worn on birthdays by a group of friends to represent an experience they shared. Jewelry has many meanings, to the artist who created it, to the wearer, to the one to whom it is passed down. Whether the jewelry has a functional purpose, an emotional significance or connects people over generations, jewelry has a certain power, (Ahde-Deal, 2013) and incorporating technology into it must go further than simply enhancing its functional purpose.

4.1.1 A functional purpose

A watch tells the time. A wedding ring or a photo locket serve the purposes of respectively, showing that one is married and providing a visual memory in the form of a photo. Aside from these functions, many heirloom pieces are emotional in their engagement. They represent something which evokes an emotional response, but otherwise lacks any specific function. The concept of functional jewelry is beginning to emerge within wearables as we see more and more ‘smart rings’ such as Motiv (“Motiv,” 2018), Oura (“Oura,” 2018) or alternatively, the BellaBeat Leaf, a necklace which measure fitness or sleep (“BellaBeat Leaf,” 2018). The topic of smart jewelry or jewelry devices has been explored extensively, such as explorations in material and form where there is a difference between interactive accessories and fine jewelry namely by the process of how they are created: “handmade using slow and time consuming crafting processes” (Tsaknaki et al., 2015). And Wallace et al, in their extensive work on jewelry devices, highlight the importance of “longevity and lasting personal attachment” as opposed to “reducing jewelry to the status of mere gadgets” (Wallace et al., 2007) and further, explains how we can use experience and sensuality to increase the richness of interaction with a jewelry object (Wallace, 2009). By focusing on the experience, we combine the functional (so-called ‘gadget’) aspect with the emotional (jewelry) aspect.

4.1.2 Designing desire

Desire in jewelry devices can be defined as both a desire to wear the device, and a desire to have an emotional connection to something, or someone. As Turner and Turner (Turner & Turner, 2013) explain, appropriation of an object, making it our own, or singularisation – the specialness of the object in the eye of the beholder are key factors in whether we are attached to our devices. Turner and Turner further reference *ensoulment* and *enchantment* and explain ensoulment as something that reflects the “owner’s identities and values” and enchantment as something which might enable future discoveries. Rose also discusses enchantment and explains that enchanted objects can fulfil a "deep fundamental human desire in an enchanting way" (Rose, 2014). Desire may be thought of as an expansion of Wallace's "enriching experiences", beyond the physical or emotional engagement, and moving towards attachment, identity, and values.

4.1.3 Combining technology and jewelry to enable connections

In their paper on silver smithing, Tsaknaki et al present "basic material manipulations" (Tsaknaki et al., 2017) and explain how they used a variety of techniques to create sensors, which were hidden in the jewelry. These sensors became part of the jewelry, creating buttons or switches which were triggered predominantly by touch, as they explained that people typically 'fiddle' with jewelry and thus, a natural interaction was to touch the jewelry to interact with it. Finally, they presented a concept of 'slow prototyping' wherein the craft aspect brought forth "'preciousness' embedded in both the actual process and the artefacts resulting from a silversmithing process". This preciousness was present in the projects presented in this work as the students are jewelry designers, and their first motivations centered around materiality, carefully selecting which materials they used and how they used these, even though we were only doing a few iterations of prototypes and not creating a final product.

Connections can also be established as linked between object, value and meaning. Jung et al (Jung, Bardzell, Blevis, Pierce, & Stolterman, 2011) explain that the links are what "really makes the difference". We are particularly interested in the links between: **people to people, a person to their sense of self, and a person to time (past, present or future).** The last link, to time, further echoes one of the aspects of the framework Wallace references, the *spatiotemporal* wherein one's perception of space and time can change relative to the other aspects of emotional, sensual or compositional (see Wright et al in (Wallace, 2009)). In each of the below presented cases, we explain how we see these links.

A holistic understanding of the bodily engagement in combination with technology (and jewelry) are to be considered, as Höök et al describe: "technologies will (depending on how we design them) encourage certain movements, certain aesthetic experiences, certain practices and understandings of our bodies—while not encouraging others. They will influence our availability for certain qualities of interaction and not others." (Höök et al., 2018).

This combination of exploration of traditional craft values (discovering through slow prototyping), links (between object, value, and meaning) and how the resulting design shapes how our interaction with technology will be (bodily, functionally, and in terms of desire, and connections) is what we aim to explore with the four jewelry devices.

5 The four jewelry devices

Figure 1. From left to right, Trace, Mirror Mirror, Connect, and Fibo. All functional prototypes. Images: Used with permission from @JewelleryofTomorrow on Instagram.

Here we present the four jewelry devices developed. Each was created as an answer to the proposed challenges, and each underwent early user research, rapid prototyping, jewelry production, and user evaluation. Each prototype was functional, using basic technologies to demonstrate more advanced future modalities so users could experience and give feedback on these early prototypes. The prototypes went through critique sessions with three advisors, one of whom is the author (external to the school), working with user centred design in hardware and product development, one (external to the school) who is developing medical devices, and one who is a jewelry designer and Associate Lecturer in design at the school. Each critique session was held with one of the advisors at a time, in person, or on the phone. Our ambition with this approach was to give the students feedback and the freedom to make their own decisions based on the variety of feedback they received. We acknowledged our role as co-designers (Eriksen, 2012) in this process; by giving feedback, guiding design choices and suggesting direction, we are inherently tied to the projects.

Below we present each concept, each prototype and how each relates to our described qualities of interpersonal connectedness. In reviewing the related works and reflecting on the links between: people to people, a person to their sense of self, and a person to time (past, present or future) we reflected on each of the four jewelry devices, determining which link was best represented by which jewelry device. This is not an arbitrary assignment of links to devices but rather a conversation, moving between what is obvious, what can be derived, and what emerges after comparing the four jewelry devices to each other.

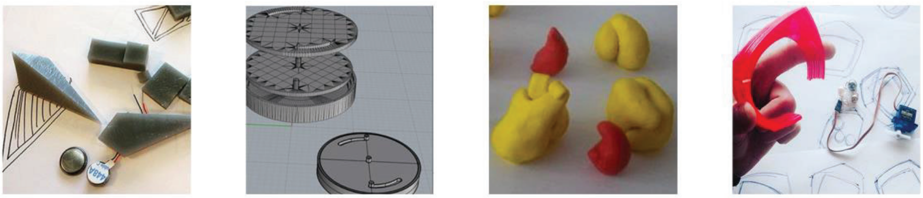

Figure 2. Early prototyping and material and mechanical exploration. From left to right, Trace, Mirror Mirror, Connect, and Fibo. Images: Used with permission from students.

5.1 Trace: Pointing to the special moments

Trace resembles the pointer of a compass, always “pointing to the special moments”[1]. Trace consists of two parts: the first, the pointer of a compass, a wearable jewelry device which, in a future device, would contain a GPS unit and a vibration motor, vibrating when a traveler retraced the journey of a loved one and found places memorable to the loved one. The second part is a piece of jewelry which represents and is generated by GPS data points, so a journey could be kept, treasured and re-visited.

5.1.1 Trace Prototype

Rapid prototyping enabled us to quickly do early user testing with Trace. As such, the Trace prototype is simple and consists of a 3D printed case with a container for a coin cell battery, a button and a vibration motor. Using design probes, interviews and focus groups as techniques to gather feedback about the concept, it was discovered that Trace was appreciated as an in-use device; something one brings out to use when they go for a walk or hike. Users preferred this over a consistent use (daily) wearable which they were not as interested in.

[1] From the Trace student-produced catalog for their final exhibition

5.1.2 Trace: Observations

Trace was presented in the student catalogue as "It gives off a light vibration to the wearer to signify your routes aligning, enabling you to walk together and discover how your loved one moved through their journey whilst you experience your own."[2] This transference of experience speaks to Wallace's description of "longevity and lasting personal attachment" and highlights the experiential part of this jewelry. The compass portion is not something so precious, but rather, the sensation it gives, is.

Trace is a representative of the link of ***people and time*** *- connecting to a loved one's past journeys, exploring new places in the current journey, and generating a piece of jewelry to be re-visited at a time in the future.*

5.2 Mirror, Mirror: Focusing on the positive moments

Mirror, Mirror aims to help women focus on the positive moments in their day. The group created an amulet which a woman touches when she experiences a positive moment in her day and at the end of the day, she can be reminded of her positive moment. One of the drivers of this concept was from the project's initial user interviews, which showed that for many of the study participants, social media was a trigger of low self-esteem and took them away from being present in their everyday life.

5.2.1 Mirror, Mirror Prototype

One of the project ambitions was to: "make the jewelry look like an amulet and give it the power of positivity." The front of the amulet is gold with a textured surface and three small precious stones. The back is a plate which rotates to open slits in the amulet's surface. For the prototype and testing, a passive RFID tag was put into the amulet, and when a woman had a positive moment, she would rotate the back of the amulet to open it. When she came home, she put the necklace on a jewelry box, and the RFID tag was read, causing an LED on the box to light up, and reminding her of her positive moment. If the wearer did not experience a positive moment in her day, then the back was not rotated and the RFID tag could not be read.

5.2.2 Mirror, Mirror: Observations

Throughout early user evaluations, women interviewed were presented with three versions of Mirror, Mirror, each with a different surface and different sets of stones – this addressed the material choices. One commented "the simplicity of the technology in the jewelry is a really beautiful idea.". The team concluded that "instead of stepping away from technology completely, you can use it to be present in the moment instead of living life through social media."[3]. Mirror, Mirror was well-received; in prototype state, it could record one recognition of a positive moment and women agreed that in future versions, recording your positive moments (plural) throughout the day might lead them to think more positively in general.

Mirror, Mirror represents the link between a ***person and their sense of self****, how they reflected and opened to a more positive existence.*

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[2] From the student's diary log book during the project.
[3] From the student's diary log book during the project.

5.3 Connect: Re-establishing physical togetherness

Connect is a set of necklaces which two friends share. Connect consists of four parts - two identical necklaces which, when put together look as if they are small shapes, hugging one another, and a box for each. When the two friends physically meet, the necklaces are "charged up". When the wearer is at home, they place the necklace on its box and the box emits light which fades over time depending on how much time has elapsed since the friends last met physically. Connect aims to disconnect from social media and focus on physical connections and being present in the moment.

5.3.1 Connect Prototype

A considerable amount of work was done to create these prototypes to ensure they were functional and realistic including casting and molding the shape, experimenting in different materials and in digital fabrication techniques to explore shape and to find out how light best permeates the surfaces, and experimenting with electromagnetism and LEDs to find out how the necklaces and boxes could work as a low-fi prototype. The final prototype consists of two necklaces which when physically connected, magnetically actuate a LED, and a box which houses a magnetic sensor, which activates a fading LED when the necklace is placed upon it.

5.3.2 Connect: Observations

The intention of the students was to "create a sentimental value, something to meet around and share"[4]. The materiality was important with Connect, the material had to be robust, but transparent, and something that was also aesthetically pleasing to wear to meet a friend. The Connect team was adamant that the necklaces were a stand-alone technology and did not connect to social media or quantify how often friends met, instead, it only focused on the next meeting. This was well received by the advisors as their sharp focus on the experience and material related strongly back to the focus on preciousness as presented by (Tsaknaki et al., 2017) and ensoulment and enchantment as per (Rose, 2014) and (Turner & Turner, 2013). *Connect represents the link between **people and people**, the formation, nurturing and growth of relationships.*

5.4 Fibo: A pregnancy wearable for partners

Fibo is a pregnancy wearable for fathers or for partners of pregnant women. Building on a near-existing product[5] which monitors a baby's movements, Fibo is a way for the father to experience the baby's movements in real time. A band worn on the wrist contains four small balls of different sizes. When the baby kicks, pushes, or has hiccups, the partner can feel all these types of movements, in real time. In this way, the partner and mother of the child can share both the emotional and physical experience of the baby's movements.

5.4.1 Fibo Prototype

The prototype began as a cloth bracelet wrapped around a vibration motor. The team looked to massage and sexual devices for inspiration and explored how pearls, metal balls, and round objects were consistently used in both ranges of products. They decided on a 4-pronged object with pearls at the end of each prong, driven by a miniature servo motor mimicking the baby's movement. A metal casing with a leather strap contains the pearls, which press against the skin via a break in the casing where the leather strap sits. As Fibo is dependent on partnership

[4] From the student diary logbook.

[5] Bloomlife (https://bloomlife.com/) currently monitors contractions and is sold on the US market. Their future aim is to also monitor fetal movement: http://www.mobihealthnews.com/content/bloomlife-gets-4m-wearable-pregnancy-tracker

with a fetal monitoring patch company, the prototype is still in a hypothetical form wherein users *can* feel the movement on their wrist but the data driving the servo motor's movement is only an estimation of fetal movement, and not currently based on real data.

5.4.2 Fibo: Observations

In interviews, pregnant couples shared their excitement of the coming baby and stated that Fibo would be a great tool for sharing the experience of the movement. Many to-be fathers and partners were especially excited to be part of the third trimester, which might be culturally specific to Scandinavia, but nonetheless was an interesting observation. Mothers were eager to share the moments and thought that the movement of the balls was relatable to the movement of the baby. Fibo was proposed as a rental, to be rented during the third trimester only, so the aspect of longevity was instead expressed in a follow up conceptual ring which would represent through its shape, the baby's movements during the third trimester.

*Fibo represents the link between **people and people and a person and their sense of self**, as both the mother and partner share an experience that otherwise happens infrequently for the partner, namely, feeling the movement of the baby. Furthermore, we posit that it could cause the partner to reflect on their own role in the pregnancy and their connection to the baby and to themselves as they become a parent.*

6 Four Qualities for human-to-human and human-to-self connections:

Reflecting on these jewelry devices and the experiences which emerged from the design, development and deployment of these early prototypes, and referring back to the categories presented in related works, especially the links which create connections (Jung et al., 2011) we derived four qualities for personal or interpersonal connections:

6.1 Desire as a driver of jewelry devices

Desiring to be more connected to the baby (Fibo), to get away from social media and connect with friends physically (Connect), or to connect with a loved one through situated story telling (Trace) were aspects of desire as a driver. However, desire could be manifested in many ways. In Mirror, Mirror, a desire to move away from the negativity of social media and focus on one's own positivity created a new desire – to be more positive. Using desire, in the form of a personal ambition or an emotional aspect was one factor in each case which can be used to explore how jewelry devices can enable human connection.

6.2 Engagement beyond useful functionality

Useful functionality was one aspect of the jewelry devices. Using Trace, you can record GPS locations. Connect acts as a reminder to see a friend. Mirror, Mirror provides a diary function, recording positive moments. Fibo allows the partner to feel the movements of the baby. However, the resulting value, the emotional links (Jung et al., 2011) which emerge because of this functionality, is what makes each of these devices something more than just functional. Trace allows people to share memories and exchange experiences, to walk in someone's footsteps. Connect facilitates a physical meeting of friends, allowing for all the benefits of non-verbal communication to have a place and time to exist. Mirror, Mirror provides a tool to reflect on, and practice positivity. And Fibo helps to establish the partner's identity and enables stories between mother and partner (Carpenter & Overholt, 2017). By focusing on engaging the user, beyond the useful functionality of the device, or the data produced by a device enabled us to focus on the experiential and emotional qualities which might emerge from using such devices.

6.3 The current day novelty and importance of an app-less device

Each of the devices was designed to be used without a screen. Although many wearables which do not have screens exist ("Hexoskin," 2018, "Spire," 2018, "Trago," 2018), there are few which operate without dependence on an associated app. One example of a wearable which does not necessarily need an app is the Nokia Steel ("Nokia Steel," 2018). It features two dials – one for the time, and one for the activity, showing the percentage of steps done in a day based on the user's ambition for their daily activity. It is essentially glanceable (Rose, 2014), the user needs only glance at the watch to get the information needed. Thus, novelty exists in the concept of a device which does not require an app for feedback. Another example is Moment, a haptic wearable which uses haptic vibrations instead of a screen for notifications. ("Moment," 2018)

With Trace, the jewelry device itself was first used to record the favorite locations of a first traveler and later used by a second traveler to feel a vibration when they were at the first traveler's favorite locations. Connect required (and insisted upon) not having any app interaction, as they could easily have incorporated a meeting planning aspect into when two friends should physically meet, but designed instead for simplicity and subtlety, giving control to the friends to decide for themselves if they would revitalize the necklaces. Fibo, like the Nokia Steel, has an app, but only for data transfer as data from the mother's wearable patch needs to be transmitted to a mobile phone which could then send it further via Bluetooth to Fibo to generate the movements. Mirror, Mirror was the closest to an app experience, as in this stage of the prototype, when the pendant was taken off and placed in its jewelry box, which lit up to show positive moments, and essentially behaves as an app might, acting as an information display. The potential for app-less devices is significant, and we ask ourselves as designers: how we can facilitate interaction and useful, timely information retrieval in a seamless, subtle way?

6.4 Using links to achieve deeper connections

For each case, we described how the links of people to people, a person to their sense of self, and a person to time (past, present or future) were utilized. We posit that these links can lead to designing for meaningful experiences, beyond the useful functionality of a device, without the use of an app, and using desire as a driver. By focusing on *people to people links*, we look to the relationship between people, how they grow independently and together. By focusing on *a person's sense of self*, we provide an aid to potentially help them explore their identity, their personal development, and their values. And by focusing on *a person in relation to time*, we can help to facilitate a discourse on how they relate to themselves and others in terms of events which have happened, which are happening and which they would like to make happen. Many wearables report on what has happened or what is happening, such as a fitness tracker telling you how many steps you've taken today, or a heart rate monitor reporting if you are in the correct heart rate zone for your current goal and activity. However, few that we have encountered focus on the future, or on incorporate past, present and future to give a holistic overview of what is possible, probable or desirable.

7 Conclusion

This work presents four jewelry devices whose aim is to investigate how we might design for future technologies which enable richer personal and interpersonal experiences via non-screen, tangible interaction.

Related works in academic research point to works which demonstrate aspects of interpersonal or personal connection, however, related on-market consumer devices are predominantly focused on providing users with data they can act on, and are far less focused on how smart products (specifically, wearables) act a conduit to improved or enhanced connections between people or between a person and their identity.

Four jewelry devices, designed by jewelry designers, are representative of how traditional craft can be combined with interaction design to promote interpersonal and personal connections in wearables. These four devices demonstrate how the combination of jewelry and technology can be used to create unique experiences and opportunities for connection which go beyond facilitating an emotional bond (such as a wedding ring) or a functional use (such as a watch). The four devices include *Trace*: a way finding device linking people over journeys; *Connect*: a set of necklaces for offline connection between friends; *Mirror, Mirror*: a pendant for training positive thinking; and *Fibo*: a pregnancy wearable for partners of pregnant women.

Using an annotated portfolio to elicit issues, values and themes (Gaver, 2012) and to discover intermediate-level knowledge (Löwgren, 2013), we present four qualities which provide future designers and companies working with jewelry and technology with a potential starting point to explore and discuss this space. These four qualities are:

- desire as a driver of jewelry devices to form deeper connections between people and between a person and their sense of self;
- moving beyond useful functionality to also consider emotional links, stories, the formation of identity, and experiential qualities;
- the novelty of an app-less device, using the device itself to communicate information; and;
- using links between people, between a person and their own self and between a person and their sense of time to achieve deeper connections and a holistic overview.

This work encourages a discourse between interaction designers, jewelry designers, technology developers and product developers to discover how to create devices which truly engage people and enrich their personal and interpersonal relationships.

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PAPER 6

ELECTRONIC KINTSUGI
AN INVESTIGATION OF EVERYDAY CRAFTED OBJECTS IN TANGIBLE INTERACTION DESIGN

Carpenter, V. J., Møbius, N., Willis, A. & Overholt, D.

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Electronic Kintsugi

An Investigation of Everyday Crafted Objects in Tangible Interaction Design

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Abstract. In the development of enhanced and smart technology, we explore the concept of meaningfulness, tangible design and interaction with everyday objects through Kintsugi, the Japanese craft of repairing broken ceramics with gold. Through two workshops, this emergent design research develops an iterative prototype: Electronic Kintsugi, which explores how we can facilitate more human-to-human or human-to-self connection through a hybrid crafted everyday object. We identify three themes: (1) enhancing human connection through embedded or "magic" technology; (2) using everyday objects to prompt personal reflection and development; and (3) exploring transferable design principles of smart products with a device of undefined purpose, and this converges traditional craft and technology.

Keywords: Craft · Internet of Things (IoT) · Tangible interaction
Everyday objects

1 Introduction

This work explores Kintsugi, the Japanese craft of repairing broken ceramics with gold and explores how we can use capacitive touch to facilitate tangible interaction with an everyday, crafted object. We situate ourselves within interaction design and look to craft and tangible interaction related works.

The grounding question for this work asks how can we facilitate more human-to-human or human-to-self connection through a digital/crafted hybrid-everyday object and which design benefits can this offer future technology? We explore this through three themes which emerge in our work about technology, craft and interaction. Much of the recent work within interaction design about tangible interaction has shown an increased focus on traditional craft work [1–4] and a return to tangible interaction [5–7] from screen interaction. Despite a focus on the craft and the tangible, in commercial areas a strong focus on app-based interaction, digital displays, and screen based solutions has become the norm, even pushing towards virtual or augmented reality. Meanwhile,

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a number of critical views about the value of the Internet of Things (IoT) have recently been published [3, 8] and a wave of research and devices around the themes of mindfulness, self-exploration, reflection, and well-being is emerging [9, 10].

In this area of overlap, between screens and tangible interaction, between making devices and traditional craft, between the IoT devices and the mindfulness tools, we find ourselves interested in exploring the potential engagement qualities of non-screen, tangible interaction in the form of everyday crafted objects. We are specifically interested in the physical nature of both the IoT gadgets and the mindfulness tools as they tie into the physicality of crafted objects. We rely on physical objects in our lives and while designing future smart homes, offices, cars, etc., we might benefit from a deeper understanding of how we relate to these physical things [11]. Núñez Pacheco and Loke elaborate: “A focus on a more reflective approach can offer fresh ways of understanding how the lived body interacts with artefacts, products and spaces” [12]. This speaks to how we can look further into understanding how humans can interact with ‘things’ and our focus is to take that further and ask how we can facilitate more human-to-human or human-to-self connection through a hybrid crafted everyday object.

2 Introducing Kintsugi as a Device to Explore Connection and Meaning Making

Electronic Kintsugi was developed as an investigation tool into how we could use everyday objects to explore human-to-human connection, human-to-self connection, and to find if we could develop something which intrigued and engaged people, moving from the IoT (Internet of Things) towards an appreciation and use of crafted, tangible, interactive, everyday objects. Electronic Kintsugi is a platform for exploration and meaning-making, an opportunity to engage with others, and with oneself and to create new narratives. In our work, our context was Japan’s artisanal craft of Kintsugi where we developed our work with a Kintsugi artist and our focus was on the tangible, non-screen interaction properties of how a device with an undefined purpose might exist in between these realms of traditional craft, technology and sound.

Inspired by Tsaknaki and Fernaeus’ work with Expanding on Wabi-Sabi as a Design Resource in HCI [13] where they explored unfinished craft and interaction design, the authors created a device and facilitated two participatory workshops exploring the Japanese craft of Kintsugi: mending broken ceramics with a precious metal to make them more beautiful and valuable than before. These concepts were adopted with the creation of Electronic Kintsugi: a sound or light reactive piece of repaired ceramics with touch interaction on the precious metal seams. Our interest is in the aesthetics of individuality, human touch, and to explore and respect the tradition of the craft of Kintsugi itself (Video of Electronic Kintsugi here: https://youtu.be/p5Pu0-gZ3u0) (Fig. 1).

Fig. 1. Electronic Kintsugi in a design expert's home; The Kintsugi artist creating traces; First workshop explorations with light and sound.

3 Related Works: Exploring the Physical Qualities of Hybrid Tangible Embedded Interaction, Through Crafted "Things"

The literature review researched works where craft is referenced for the transferable physical qualities of interaction design; material, texture, touch, and recognition of craftsmanship as opposed to the sleek smooth, machined surfaces of our current smart products. We see this as a natural progression from a screen-based society, moving towards embodied engagement and beyond the swipe-interaction of the "black mirror" (screen) as described by Rose [14]. Three thematic findings informed our prototype and workshop development.

3.1 Traditional Craft as a Starting Point for Exploration

Tsaknaki and Fernaeus explore craft in depth, in a variety of their works, and hereby evaluate the role of interaction design in craft. In their work on Wabi Sabi, Tsaknaki and Fernaeus [13] present the concept of Wabi Sabi; and "approach perfection through explicitly unfinished designs". We embrace the concept of unfinished design with Electronic Kintsugi, deliberately designing an unfinished device to prompt curiosity and exploration of the prototype. In their work with leather, Tsaknaki, Fernaeus, and Schaub [15] explore how leather can be a touch based, rich material for tangible interactions. This work informs how we can look to everyday materials, in our case, ceramics, for stroking interaction, much like the leather interactions of their SoundBox.

In exploring silversmithing, Tsaknaki, Fernaeus, Rapp and Belenguer [16] both engaged local artisans and focused especially on the "cultural and historical significance" of the craft, and explored the design "space of screen-less" interactions. This finding informed our choice of working with the Japanese artisanal craft of Kintsugi where we developed our work with a Kintsugi artist and our focus was on the tangible, non-screen interaction properties of how a device with an undefined purpose might exist in between these realms of traditional craft and technology.

3.2 Designing from Everyday Things with Social Implications in Mind

In recent works about the Internet of Things (IoT), Cila, Smit, Giaccardi and Kröse [8], Nordrum [17], and Lingel [3] all explore the social significance of the "thing" and suggest that we need not only look at the everyday (home and workplace) but also the social and cultural implications of these everyday interactions with things. Our work focuses on this "thing" and thus, the development of Electronic Kintsugi.

3.3 Technology and Touch

Significant work has been done in the field of interaction design with regards to touch and in the interests of space we do not cover that here, however the particular work by Cranny-Francis [18] covers a sizeable portion of the touch research done within design. In Semefulness: a social semiotics of touch, Cranny-Francis introduces the experience of touch as 'semefulness' – "multiply significant, physically, emotionally, intellectually, spiritually, politically" [18]. She describes the 'tactile regime' of touch in culture, how it shapes how we engage with one another or to the tools we design and then use. She describes that "Touch is semeful in that it is full of meanings - physical, emotional, intellectual, spiritual and those meanings are socially and culturally specific and located." Here we can begin to touch upon the multi-faceted nature of Electronic Kintsugi. It is culturally and location specific to traditional Japanese craft; it is emotional to some - as an heirloom or a piece of valuable art; it fosters social interaction when acting as Electronic Kintsugi (see Sect. VI. C); and it is physical in nature, it requires touch, stroking, holding the bowl. One ambition of Electronic Kintsugi is to enable meaningful experiences for the participants, and by addressing Cranny-Francis' 'semeful' attributes, we may begin to explore this domain.

3.4 A Focus on Audio and Playfulness

Schoemann and Nitsche [4] use the "Stitch Sampler", a sew-able musical instrument to focus on embodiment via the act of sewing, and on audio feedback, "to respond to the crafter's personality". These qualities of craft, tangible non-screen interaction, and playfulness with sound inform our process, helping to frame the area we are exploring.

Electronic Kintsugi allows participants to explore the interaction qualities of a hybrid crafted device and consider its potential uses in their lives. We encourage curiosity and unexpected encounters, and reflections of those encounters. This speaks to our objective to inform future smart product design and encourage a tangible, non-screen interface which utilizes craft and the qualities of curiosity and reflectivity.

4 Methodology

Initially, we were fascinated by the idea of Kintsugi and made a basic prototype to explore possible values of Electronic Kintsugi. This work spans from the first prototype to two workshops, one in Japan, and one in Denmark, six months apart. We present an overview of methods here and then describe each workshop and the findings in the following sections.

4.1 Workshop 1: Methods

The first workshop was designed in a collaborative process with FabCafe Tokyo and Kintsugi artist, Kurosawa where we combined electronics with an everyday "craft" object with the artisan in this process [16] so they could both introduce us to the nuances of the craft and help us to understand to what we should be paying attention.

Following the process described by Tsaknaki, Fernaeus and Schaub [15] in their leather material explorations, we created a workshop session to explore the properties of Kintsugi and gain insight into the craft, and to investigate how our prototype was received by participants in that context.

We used thin strips of copper tape to conduct electrical current and worked with the Kintsugi artist to carefully overlay the traces of precious metals where the repair had been, to emulate the traditional Kintsugi.[1]

The workshop consisted of two of the authors (one, an electrical and mechanical engineer and the other an interaction designer), the Kintsugi artist, and seven participants of varying electronics skill levels who were recruited through an open Fabcafé Tokyo Facebook event.

During the workshop, the Kintsugi artist presented and demonstrated their process, allowing participants to try their hand at creating Kintsugi. The authors presented their work and the thoughts behind the Electronic Kintsugi. The workshop explored Kintsugi and interaction with it, using two familiar outputs, sound and light, which would act as examples of possible outputs, so that participants were able to extrapolate from this in terms of what the Electronic Kintsugi might be used for.

We conducted the workshop in a focus group style, and did two rounds of explorative, hands-on evaluation. A questionnaire was developed to capture their experience (Results in section "First Workshop").

4.2 Second Iteration of the Electronic Kintsugi

Cila, Smit, Giaccardi and Kröse [8] describe the interventionist product, for creating dialogues, which sense, respond to, and interpret data. The Electronic Kintsugi was developed to sense touch, responds to it, and for the second workshop, could interpret data, such as how often it is being stroked.

After feedback from the first workshop, the Electronic Kintsugi was updated to have more responsiveness and a more light interaction would emerge, or how it would progress in order to prompt explorative and playful behaviour with the device. Rather, it had a certain level of ambiguity [19] via the programmed adaptive behaviours, based on how much it was interacted with and for how long, e.g., if it had been left alone, or off for a period.

[1] http://www.kurovsya.com/.

Several touch-to-sound and touch-to-light reactions were developed for the workshop. Each reaction was taking input from the touch interface[2] and creating a specific output in the form of either light or sound. Light was output on a strip of NeoPixels and sound was synthesized using a software library[3] and output to a speaker.

The light reactions transform a single parameter from the touch interface into a specific light pattern on the LED display. Likewise, sound reactions transform a single parameter from the touch interface to single tones, chords or evolving sound figures.

In the second iteration, we wanted to increase the complexity [20] of interacting with the device so the interaction was less binary, such as a touch = a sound. Instead, it was decided to make the coupling between the input and output less apparent, giving it the autonomy to interpret the frequency of interaction and respond according. Within the second iteration algorithm, there exist five cases for interaction modalities for either sound or light, meaning five for sound and five for light. There is a manual switch on the Electronic Kintsugi so participants can choose if they are interacting with light or sound. These five cases were five variations in types of output cycled through a timer based on interaction. If the user was interacting with the Electronic Kintsugi, then it would remain on that mode longer, until they paused interacting, to not interrupt their flow of interaction. Then it would move to the next mode. Each mode was a variation in output, so for example, for sound, it might be different chords or tones.

This had the purpose of giving the participant less time to recognize patterns in the behaviour and enhance the user's curiosity. We focused on how the interaction between the participants and the Electronic Kintsugi could be more tightly or loosely coupled, yet also incorporate elements of surprise; and what implications this interaction had for the participants' association to the Electronic Kintsugi as a device, versus as an instrument, companion, or tool.

4.3 Workshop 2: Methods

The second workshop was scheduled six months after the first, due to travel and revisions to the technology and workshop design.

Approaching workshop two, Wakkary et al. [11] published a work, "Morse Things" wherein they utilised a methodology for engaging design researchers to evaluate their everyday object through having the object in their home for some weeks, and then following up with a workshop with the design researchers to explore the experiences with the object. We adopted this methodology for our work, and asked four design researchers to evaluate the Electronic Kintsugi in their homes for a period of five weeks followed by a workshop. We chose to use this method, in agreement with Wakkary et al. who explain, "A key motivation in our approach was the desire to deepen our investigation by including a wider range of experts that have the design expertise to perceive and investigate the nuanced and challenging notions of thing-centeredness."

[2] We followed instructions from: http://www.instructables.com/id/Touche-for-Arduino-Advanced-touch-sensing/.

[3] We used this library: https://github.com/dzlonline/the_synth.

4.4 Participant Selection and Introduction to Electronic Kintsugi

Opportunity sampling was used to select experts in design research from different backgrounds, aged 30–38, living in Copenhagen to ensure different perspectives on the experience and imagined future uses. Participants' names have been changed for their privacy. Their backgrounds are crossovers between the fields of engineering, interaction design, dance, performance design, industrial design, robotics, and hardware development.

Participants were recruited by email and it was explained to the participants that they'd have the object in their home for 5 weeks and engage with it for a minimum of 15 min per week, spending another 15 min per week journaling their experiences. Participants were asked to keep a record of their thoughts and experiences and to both keep these as a document and bring these thoughts to the workshop at the end.

We found four researchers who were available to review the device worked. Our goal here was to invite these experts to explore with us and find out what questions to ask participants [21].

We describe the specific methods we used during workshop 2 in the section "Second Workshop" to maintain continuity and legibility of this work (Fig. 2).

Fig. 2. Touching the traces on the Kintsugi bowl with the Electronic Kintsugi boxes displaying light and playing sound.

5 First Workshop: FabCafe Tokyo

Workshop 1 informed our work and to set the scene for workshop 2. The workshop was conducted in both English and Japanese, and participants could communicate in their preferred language. We used a written questionnaire so participants could answer in their preferred language. We briefly present workshop one and then move to reflect on findings from workshops one and two.

After a brief demonstration of function, the Electronic Kintsugi was explored by participants. They touched the traces with one, two or all fingers, and tried turning the ceramics over, holding it in one hand or two. We explained "the output could be anything, it could start your car, or feed your pet".

Since participants were familiar with the interaction technique after exploring the sound interaction, the light interaction had a much different approach. Participants knew how they could touch it, with one or several fingers and they now focused on light or harder touches, strokes, or resting their finger on the traces. The light was much more unpredictable than the sound. Whereas with the sound, they were acting almost as musicians, experimenting to find patterns and particular notes, with the light it was more about getting a bigger or smaller reaction than it was about the nuances in between these small or large bursts of light. One participant asked, "I want to know how much it's me that is controlling it and how much it is doing on its own".

5.1 Findings

We highlight several responses here from the questionnaire to inform future researchers in this field who might be interested in working further with this.

- Encouraging senses and emotions
  - Being able to handle the Kintsugi was a special experience, "There is a different feel to a real Kintsugi. It's rare to see the hitting of the device so profoundly." (P-1A) and "We're often not given permission to touch traditional art. It feels good to be encouraged to touch it." (P-1E).
- An interest in other senses: taste, smell, and food
  - One participant who suggested it be used as a bowl to eat from "Japanese people eat with bowls close to their mouth, so I want to see some sound installation when someone is eating" (P-1A) and another who suggested that it could be used for a cat or dog food request device "imagine the cat's tongue licking the Kintsugi!." (P-1C).
- Light – Unpredictable but has potential
  - One participant noted that the light reminded them of a starry sky and stated, "In a larger, or aesthetically ordered or different setting (night), it would be very soothing" (P-1C). Another participant was inspired and shared an idea "The combination of the craft and the touch with the light feedback reminded me of the challenges of regaining fine motor control in a finger after an accident. The focus required and the tranquility of the lights may be a fun alternative physical therapy." (P-1E)
- Sound – Alive characteristics
  - One participant remarked, "Craft has character, especially as it ages. How might that character be represented as sound? I feel the sounds were lovely but not aligned with the character of the craftwork. Or maybe it had juxtaposition of sound quality and physical character which enhances the contrast between tradition and technology." (P-1F). Two participants related to the object in an anthropomorphic way, stating "It was like the cup was telling me how he/she's doing. Since Kintsugi part is a past wound, sometimes I felt like it's telling me it had pain." (P-1E).

5.2 Findings Summary

The workshop provided us with some considerations about the role of art and objects and potential interactivity from these objects. Participants were excited to play with art and traditional craft based objects. They were fascinated by the light and sound output and could extrapolate to imagine other interaction scenarios. They explored the aesthetic interaction qualities and played the Kintsugi like an instrument, using expressive hand gestures to explore the touch interaction. And they could reflect on the role of technology and tradition and how we live our lives: "Developing a closer, more physical relationship with the objects in our lives feels meaningful." (P-1E).

6 Second Workshop: Copenhagen

To prepare for the second workshop, we asked participants to spend 20 min in silence [22] to complete a written activity to gather their pre-workshop thoughts and feedback prior to engaging in dialogue.

We used Kujala, Walsh, Nurkka, and Crisan's [23] method of sentence completion to extract these initial reactions. We provided the instructions that participants should answer quickly (20 questions in 20 min) and the beginning of the sentence was given, which was then completed by the participant in a way they saw fit. Kujala and Nurkka [24] used categories of user values to classify questions. In Fig. 1, one can see the sentences we defined, as per each value category. We tried to make a nearly even number of positive and negative questions, and allowed extra space if they wished.

6.1 Sentence Completion Tool

General
• Using Electronic Kintsugi these past weeks has been ____ (1 Word) • Social values • I felt a sense of achievement when • I felt a sense of disappointment when • I felt like I was controlling the Electronic Kintsugi when • I felt like the Electronic Kintsugi was uncontrollable when • I felt connected to the Electronic Kintsugi when it

Emotional/hedonistic values
• The emotion I felt when using the musical aspect of the Electronic Kintsugi was mainly • The emotion I felt when using the light aspect of the Electronic Kintsugi was mainly • My best experience with the Electronic Kintsugi was when

Stimulation and epistemic values
• I experienced curiosity when the Electronic Kintsugi • I thought it was novel that the Electronic Kintsugi did • I learned something new when the Electronic Kintsugi • I was frustrated when the Electronic Kintsugi • I felt a desire to use the Electronic Kintsugi when...

Growth and self- actualization values
• While using the Electronic Kintsugi I reflected about • The Electronic Kintsugi helped me to • The Electronic Kintsugi failed when

Traditional values
• The Electronic Kintsugi fit into my home because • The Electronic Kintsugi was out of place in my home because • The Electronic Kintsugi was an interruption when it

A Likert scale [25] was used to determine their reactions to sound and light interactions. We asked participants to rate the light and sound interaction. For light, we asked "I found the light output to be:" and gave one of the scales the value of "Calming" and the other end of the scale "Attention Seeking". For sound, we asked the same, but added an additional scale of "noise" to "music".

We spent the remaining 2.5 hours engaged in a group discussion about their experiences, comparing, contrasting, and exploring possible future interactions.

6.2 Findings of Workshop Two

We used mind mapping as a technique to map out the responses from the discussion and journals [26]. We present here the results of the sentence completion as well as the discussion and journals.

6.3 Sentence Completion

We compared the sentence completion responses sentence by sentence and by category. The Electronic Kintsugi was described as “enjoyable, calming, interesting, and different” in the one word descriptions. The findings from participants, ordered by the Sentence Completion Tool headlines [23] were:

General: Participants felt a sense of achievement when interacting with others and felt connected to it when it: “reacted to my own and others touching it”.

General: Predictability. They were disappointed and frustrated with the light interaction: “the light interaction was unpredictable, non-responsive and not interesting”. It is noted here that in both workshops, the light was reported to be not as responsive as the sound input. Participants in both workshops reported that they were more fascinated with the sound feedback, particularly because there were more nuances in the sound than in the light.

Emotional: Participants described their emotional response as “playfulness and companionship, calming, joy and puzzled” and again highlighted their frustration with the lights, describing them as “underwhelm(ing), disappoint(ing), and distanced”. Two participants referenced the social values and stated that their best experiences were while playing with others.

Stimulation and epistemic: Participants described the changing soundscape, mentioned their desire to use it when someone asked about it.

Growth and self-actualization: Participants described both, relaxation and concentration as well as creative thinking and social interaction as outcomes of their interactions with the Electronic Kintsugi.

Traditional values: Participants noted that, as an object in their home, it was “cute and modern”, “playful and interactive” and that it “combined ceramics with playfulness”.

Finally, in the extra space provided, three responses were thought provoking

- I kept receipts in it and I liked how it became less precious and more functional
- I wonder if you were tracking my use
- It was a search into new creative possibilities.

The Likert Scales gave us the below results, indicating that while results varied, light was generally thought to be more attention seeking than calming, sound was found to be generally more calming than attention seeking and sound was more musical than noisy.

"I found the light output to be:" (Calming = 1, Attention Seeking = 10)	Average rating of 5.75 (Actual Rating Values = 8, 4, 4, 7)
"I found the sound output to be:" (Calming = 1, Attention Seeking = 10)	Average rating of 3.75 (Actual Rating Values = 3, 3, 7, 2)
Extra question for sound: (Noise = 1, Music = 10)	Average rating of 6.25 (Actual Rating Values = 6, 5, 5, 9)

From the discussion and journaling, three primary categories of interest emerged: (1) enhancing human connection through embedded or "magic" technology, (2) using a craft based object in prompting personal reflection and development, and (3) exploring transferable design principles of smart products with a device which has no defined purpose, and which converges traditional craft and technology. In the accounts below, participants focused primarily on the sound based interaction as they were not interested in the light interaction and spent most of their time with sound (Fig. 3).

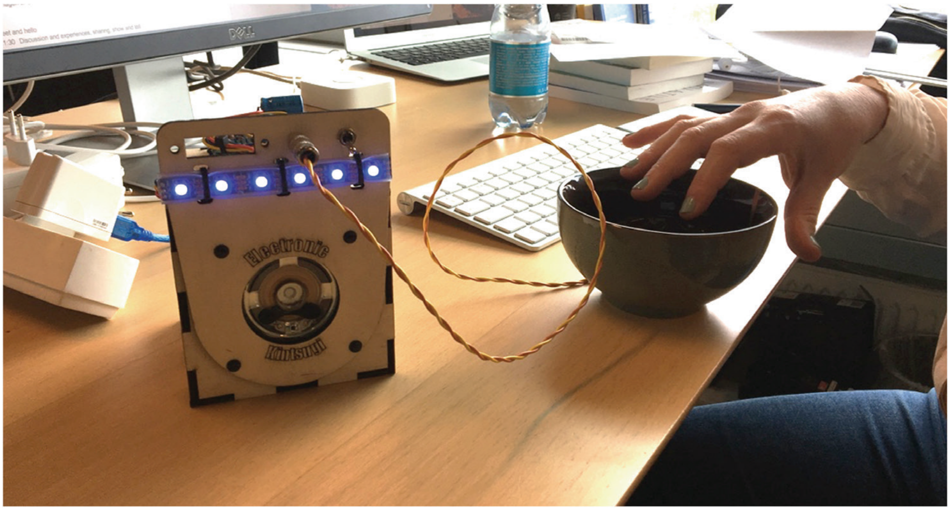

Fig. 3. The Electronic Kintsugi bowl with a design researcher, she is playing with the light as a break from work.

7 Three Themes Identified

7.1 Enhancing Human Connection Through Embedded or "Magic" Technology

There were several accounts of how the Electronic Kintsugi sparked social connections and interactions. Antonio had placed it in the kitchen and he explained that the bowl on its own might not have sparked curiosity but the box did and visitors asked what it was and then wanted to play with it. For Sandra, she was having an evening of entertaining guests, and as they were finally leaving (she was tired), she stood in the doorway, and absent-mindedly touched the bowl as they were putting on their shoes. The guests became immediately intrigued and asked questions and wanted to play with it, which was both charming and exhausting, since, as Sandra explained, she was ready for them to go home, but also happy to play and show them the bowl. For Henry, it was a social life saver as he suddenly found himself spending time with his father in law who doesn't speak much English, and Henry doesn't speak much Danish. The Electronic Kintsugi came to the rescue as a medium they could explore together, without a need for verbal language. Martin explained that he took it on the bus and it was "totally inappropriate" there, it was loud and kept making screeching noises. He was frustrated with it, and imagined if it was quiet and making nicer sounds as it often did (though, not on the bus) then he could have asked others to join in on the playing.

The 'magic' of the object was intriguing to people who didn't know what it was and sparked both play and conversation, even, in Sandra's case, when they should have been leaving. It offered a needed social lubricant in the case of Henry and sparked ideas on how to engage strangers on the bus for Martin. Having an everyday object have 'magical' and unexpected properties, without being a gadget, or being used for some other purpose (a fancy remote, a communications device, etc.) seemed to be the key to sparking this social interaction. Unexpected qualities of playfulness via a changing soundscape were the right recipe for the Electronic Kintsugi.

7.2 Using an Everyday Object in Prompting Personal Reflection and Development

Our experts felt that an everyday object combining traditional craft and technology was important, commenting that they "wanted to come back to it again, it levels up, it evolves over time" (Martin) and "I love that it's not intuitive, you have to spend time with it and get to know it. It's nice that it doesn't have a defined purpose, somehow it's good to just have something nice and electronic in your home, especially with the copper tape, it feels like a crafted aesthetic, you can see craft, and the time put into it, but you can't see code, so somehow this makes tangible the craft of the code". (Henry). Sandra likened it to a "Tibetan singing bowl, you have to hit it just right and there's a pleasure behind controlling that energy". And Martin continued, "The electronics force you into movement, I've never done this with an Ikea bowl".

Bringing together physical and digital materials, considering both the craft of the object and the craft of the code, and, considering the social surroundings that the object inhabits were important aspects of creating a hybrid craft [16].

For us, it is the combination of these things which is a significant part of designing for meaningful interactions and experiences when working with future smart everyday products in the home.

7.3 The Role of an Object with a Non-defined Purpose

The fact that the purpose of the object was open-ended was well-liked, and the participants used this opportunity to explore the possibilities with it. Some of their comments included "I love that it's not intuitive, you have to spend time with it and get to know it" (Martin) and "It was interesting, as a dancer, that I played a lot with the hand movements and did improvised hand movements" (Sandra).

It was briefly discussed what it might be like to grow up with an object like this in your home, instead of an iPad or TV, and how that might change your perceptions of how you interact with the world, and come to appreciate objects. Sandra explained "I prefer it as an ornament, something non-connected. It can be a companion, or a container, such as for my receipts." The combination of a non-defined interaction purpose with the functionality of a common object, a bowl, seemed to work well to invite playful and curious interactions.

While some experts poured water into the bowl to explore the sound, Antonio took it a step further, and ate his breakfast cereal from the bowl, "it made me aware of how fast I was eating". (Interestingly, in workshop one, this was a suggestion from participants, that it could be nice to eat from the bowls). The choice to use a bowl came from our fascination with Kintsugi and the tendency there to repair bowls, and we learned that as a starting object for this exploration, a bowl has so many inherent properties, something to eat from, to store things in, as a decorative object, as a historical object, it's nice to hold, and it exists in many cultures, and many homes.

Creating an object with non-defined purpose can be one way to encourage curiosity, playfulness and an opportunity for the creation of meaningful or important moments in one's life, especially when there is a human-to-self (self-development) or human-to-human (social) aspect. On the contrary, further interaction design would be necessary once an object moves beyond being something with a non-defined purpose. In this work, our focus on a non-defined purpose is not disregarding designing interactions for a specific context, but rather our focus is on designing interaction concepts at an earlier phase of the project development.

8 Discussion

It is worthwhile to revisit Borgmann (as described by Fallman [19]) here, who worried that technology would "turn us into passive consumers, increasingly disengaged from the world and from each other" [19]. Our aim with Electronic Kintsugi, and a focus on designing for ambiguous interactions with everyday objects, is to move back towards each other, towards engagement with familiar objects, towards creativity and playfulness and that it is "not simply [a] neutral means for realizing human ends, but actively help[s] to shape our experiences of the world" [19].

Despite work in academia developing tangible, non-screen devices or criticising IoT (as earlier presented) the products which emerge on-market today are not abundantly reflective of this. These products do not necessarily engage people on a human-to-human or human-to-self level and instead, often cater to fixing a small problem without necessarily considering a more holistic impact. Cila, Smit, Giaccardi and Kröse [8], describe the current approach to IoT as being short-sighted and emphasize the potential for the role of interaction design in new smart things. In our work, we expand on this, and emphasize a need for smart things to perhaps be rooted in craft to enhance meaning-making, to utilize non-screen interaction, and to move towards facilitating human-to-human or human-to-self exploration.

We further emphasize the role of a device with an undefined interaction purpose, as opposed to the very specific devices emerging on market today such as smart candles[4] (controllable via app) or smart hair brushes.[5]

Although we needed to use copper tape to achieve the conductivity, in the future, we would like to explore which material properties would allow a Kintsugi artist to create something more conductive using the traditional precious metals. Given this, the most significant aspect was the conceptual consideration of how one might interact with an object which had been created by an artist, but is otherwise an 'everyday object' (one which we might find in our homes anyway, such as a bowl).

Returning to Cranny-Francis' semefulness, we can see the aspects of physical, emotional, intellectual, spiritual, social, and cultural [18] in the Electronic Kintsugi. We essentially augment a crafted object with technology, with the aim of created an enchanted [14] everyday object with a historical, crafted background which is open to interpretation and explorative play. The role of an enchanted [14] everyday object is especially important to consider in a world of increasing IoT gadgets. Considering a future vision of connected everything, we feel it is important that we do not become too focused on the technology, such as having RFIDs under our skin [27] or being laden with smart tablets, smart watches or smart water bottles; but rather, that we embrace humanness.

We want to create devices which provoke thoughtful and critical reflection, and engage people on a tangible level; not just a screen asking if you've been mindful today [28]. When considering the design of new 'smart' objects, we should perhaps ask, "does it need to be connected, and if so, why?", or "how can I enhance the existing values in this everyday object?" A door handle for example, doesn't just open a door, it is the literal door to coming home from work, relaxing after a long day, seeing your family again, and more.[6] The affordances inherent in everyday objects are many and it is our job as interaction designers to not only invent new technologies and uses but to consider how to support these values and avoid turning the objects in our world into cloud-connected gadgets.

Electronic Kintsugi embraces new technology and established craft practices, emphasizing curiosity and playfulness while facilitating interaction between people and the self. Furthermore, we felt that the aspect of craft was a key identifier in what made the everyday object special. The history and delicate quality of the Kintsugi had multiple reactions, the participants in Japan were intrigued that they were allowed to play with a piece of art, and the participants in Denmark were eager to engage with, and learn more about Kintsugi. Our primary concern was the investigation of a non-screen, tangible everyday object coming from a place of craft, and in future work we hope to further investigate how we could work with a Kintsugi artist to create a fully functional piece of Electronic Kintsugi, with capacitive traces in the piece.

[4] https://www.ludela.com/.

[5] https://www.kerastase-usa.com/connected-brush.

[6] From an interview with designer Carl Alviani (http://meaningfuldevices.vanessa-carpenter.com/2017/08/10/anything-but-personal-is-a-failure/).

9 Conclusion

In this work, we have presented Electronic Kintsugi: an exploration in how an everyday object (a bowl) in combination with artisanal craft (Kintsugi) and electronics (conductive sensing) could result in more human-to-human connection and human-to-self development. Through two workshops, one in Japan with a Kintsugi artist and participants, and one in Denmark, with design research experts, we explored the properties of this Electronic Kintsugi, an interactive object with no defined purpose and two main interaction outputs - sound and light. We found that sound as feedback was of significant interest due to its nuanced nature and reactiveness, and between workshops, the sound was programmed to evolve over time with use.

Using copper tape, we augment a traditional, crafted object, namely, Kintsugi with electronics, and call it Electronic Kintsugi, creating an open platform for play, exploration and development. In future work, we hope to continue work with Kintsugi artists to find a material which can be used in the craft practice, which would also be conductive enough for Electronic Kintsugi.

We identified three categories of reflection from our studies with participants, and areas which future smart products can look to, to enable more meaningful interactions between human and human and human and device. These categories are: (1) enhancing human connection through embedded or "magic" technology, (2) using everyday objects to prompt personal reflection and development, and (3) exploring transferable design principles of smart products with a device of undefined purpose, and which converges traditional craft and technology.

Finally, we discussed that as interaction designers, we would like to focus on embracing humanness in future technology designs and could look to the values and affordances inherent in everyday objects to bring out these values and design for these moments in our lives.

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PAPER 7

FROM SEX TOYS TO PLEASURE OBJECTS

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This research works against essentializing notions of sexuality, gender and pleasure within the design of sex objects through proposing and developing the design of DIY kits suitable to manipulate and customise what objects designed for sex mean for the individual and their role in society in relation to gender and sexuality. This paper outlines a series of participatory workshops where artists and designers were invited to contribute to the design of the DIY kits. Three artistic works emerge from the workshops as beta DIY kits, alongside a future work of a DIY electronics kit and an online collaborative platform. These workshops led to the shift of focus from sex objects to pleasure objects.

Sex, Feminism, Participation, Pleasure, DIY, Kits, Future Technologies, Future Pleasure Objects

1. INTRODUCTION

The design, form and function of technologies designed for sex and pleasure communicate societal norms, taboos and cultural beliefs around the topic (Bardzell and Bardzell, 2011). This research employs a feminist lens to challenge the design of sex objects that dictates what kind of sex we should be having. For example, the primacy of phallic sex toys for women dictate a heterosexual notion of sexuality. We propose that many devices designed for sex perpetuate universalizing and essentializing ideas of sex acts, sexuality and gender. We explore the concept for an alternative design in the form of a DIY kit. Instead of finding the answer to the question of “what people really want” in terms of sex toys, we propose giving users the tools to get creative and find out for themselves.

As HCI moves into its third wave (Bødker, 2006), humanistic topics and human concerns within the design of technology for our daily lives have emerged. Pleasure as a measure of HCI is being increasingly popular (Huta and Ryan, 2010, Hassenzahl et al, 2013, Diefenbach, Kolb and Hassenzadl, 2014, Mekler and Hornbæk, 2016) and researchers have pointed towards a focus on sex in HCI, such as the Sex & Bodies session at CHI, 2011 (Bardzell and Bardzell, 2011) and (Eaglin and Bardzell, 2011) or the article by Blythe and Jones (2004) encouraging more research into this area. Homewood and Heyer, 2017 explore what the digitalisation of contraceptive methods means for rituals around sex and parenthood.

The overall ambition of this research is to advance the vision of what sex objects could be and do in order to help mediate autonomous and non-binary articulations of desire and the machine. We do this through holding participatory workshops, where invited participants can explore and experiment together in developing a DIY kit. We are exploring both currently available technologies and speculating about what we would like to have at our disposal in the future. Culminating from the workshops, we present three artistic works created under the title of “Future Pleasure Objects” and conclude with a future works section, speculating on how communities, artists, technologists, and politics will create and relate to pleasure objects in a post-porn reality.

Alongside the concept of the DIY kit, including the three example kits: the artistic works, a third contribution of this research to the field of HCI is the discussion based on the shift within the story of this research from “sex objects” to “pleasure objects”. This is based upon observations from the workshops and appears to reflect a change of attitude in participants and organisers in regards to sex once the boundaries of the design of sex toys are breached and alternative materialities and forms are possible.

2. METHODOLOGY

2.1. Feminism

To re-imagine what sex means to us through designing alternative sex objects is to trouble norms in society. Our motivation behind this is inspired by a feminist perspective. We are strongly influenced by Donna Haraway's social constructionist approach to science, and therefore embrace situated knowledge generated in the workshops (Haraway, 1991). Haraway sees objects as 'boundary projects', boundaries manifest through social interaction. This is our motivation behind adopting a design-based method, where the objects themselves trouble, re-imagine, and propose alternative boundaries in and of themselves.

Third wave feminism is often associated with a sex-positive and queer approach to feminist discourse, art and activism. This approach tries to avoid the mistakes of second wave feminism, which was critiqued for having painfully replicated racism and colonialism (Ahmed, 2017), as it only considered and benefited white middle class heterosexual women, while the feminist struggle of authors, artists and activists not falling into these norms were rendered invisible. It was also critiqued for focusing too much on the risks of sexuality (abuse, abortion, rape), instead of taking back our bodies as autonomous sites for pleasure. Third wave feminism therefore tries to approach issues intersectionality, being aware of all intersecting discriminations a person has to deal with (for example racism intersecting with sexism, heteronormativism intersecting with classism) (Mohanty, 2003, p.7). And at the same time encouraging ownership of bodies, and embracing sensuality, sexuality, lust and love.

In third wave feminism 'Gender' is not believed to be binary - male or female - but instead being enacted and performed by a person in every moment of life. Hence, gender performance is not equal to biological sex or to sexual orientation. This kind of questioning and unsettling of representationalist politics (Barad, 2012) enables new artistic experiments to emerge. They allow artists to construct authentic ways of feeling, sensing, touching, relating, enjoying, caring, desiring based on their own diverse and fragmented experiences. New technologies play a crucial role in enabling these experiments, pushing the limits of cognition and merging borders between human and non-human. Queering and constructing intimacy through pleasure objects this way becomes a form of world-making.

In de-constructing and re-constructing the design of sex toys into a DIY kit, we create new, more moveable boundaries around how sex objects dictate what kind of sex we have and what sex means to us as individuals. We therefore argue that feminism is our methodology, and follow Bardzell, (2010) in advocating for participatory methods when designing for plurality and inclusive designs.

2.2. Design Anthropology

Design anthropology (Gunn, Otto & Smith, 2013) was chosen as the vehicle for this research due to the possibilities it allows for designing for the future through a critical investigation of existing concepts around the body and technology. Design is oriented towards the future while anthropology provide contextual knowledge and allows for theorizing the usage. Design anthropology was chosen because it allows us to combine observations, iterative actions and reflections throughout the development process.

Rather than making statements about what is, design is concerned with creating what might be. (Gaver, 2012). In this work, we invite artists and researchers to collectively discuss, debate and create, wherein each iteration, whether it be a workshop or an artefact, generates new formulations of what future pleasure objects might entail, and broadens the scope of what is possible while simultaneously creating limitations on what we mean by future pleasure objects.

3. RELATED WORK

An important aspect of design anthropology is to gain an understanding of the current culture in order to create something new (Gunn, Otto & Smith, 2013). Therefore, as preparation for the workshops existing artistic and technology projects relating to the body were studied in order to provide a research-based framework.

3.1. Contemporary Art and the Body

Contemporary art since the 1960s has used the body as a canvas and as a means of expression. Over the years, artists increasingly claimed ownership over their body and counteracted various forms of external appropriations. To limit our field of research we have focused on works of art affiliated with technology and the DIY culture and include artists who apply scientific knowledge to influence their body in a subtle and subversive manner. For example in *Mary Magic*, an 'estrofemlab' helps to extract estrogen from body fluids to increase the estrogen level and show the 'Micro Performativity of Sex Hormones' (Tsang, 2016). Alternatively, *Heather Dewey-Hagborg*, who collects strangers' DNA such as hair or skin particles in public space to reconstruct their identity (Dewey-Hagborg, 2014). And the artist group *Pechblenda*, when they develop first aid gynecological tools to 'decolonize' the female body (Gynepunk) (Pechblenda, 2015). They all approach intimate and private - for others, invisible or hidden - body parts, functions, sensations, circles and inner dynamics. Giulia Tomasello follows the same strategy of subtle intervention when she hides DIY biotechnologically treated panty liners in female underwear (Tomasello, 2018) in order to prevent vaginal infections, emphasizing the immense impact of consistently present microbes and bacteria on our body.

These projects embrace the body, inhabit it consciously and seize it as site of artistic intervention to increase well-being, health or pleasure. This ambition is usually monopolized by industries such as the pharma industry. This kind of 'taking back the body' results in a curious exploration on the intersection of art and science. Our project aligns with these efforts in the sense that we follow similar strategies, encourage similar DIY and citizen science practices and share similar perspectives.

3.2. HCI and the Body

The very nature of Human Computer Interaction (HCI) and Interaction Design is to explore the human in relation to technology and vice versa, and there exist a subset of fields relating specifically to exploration of the body and bodily engagement. Höök et al, (2018) in their work on soma-based design, introduce and explore somaesthetics (the perception of the body and experiences therein) and describe how user experience can be described as "a living, purposive, sentient, perceptive body or bodily subjectivity engaging in meaning-making processes" (Höök et al, (2018)). With this lens we look towards related technologies in this work. Núñez-Pacheco and Loke explore how wearables acting on the body (in their case, a vibration motor encased in a scarf) can facilitate a dialogue between "soma and intellect" (Núñez-Pacheco and Loke, 2017). This points to how technology, acting on the body, can be a facilitator of an experience, instead of transmitting digital information (such as a notification). In the Skintillates project, extremely thin circuits are built into temporary tattoos, demonstrating how skin can be used as an interface (Lo et al, 2016). Haptics are used extensively in bodily interaction and not always for transmission of digital information. The Hedonic Haptics player (Boer, Vallgårda and Cahill, 2017) is a device which is worn on the body and transmits vibrotactile patterns as a form of experience. In "How Bodies Matter: Five Themes for Interaction Design", Klemmer, Hartmann and Takayama (2006) explain, "One of the most powerful human capabilities relevant to designers is the intimate incorporation of an artifact into bodily practice to the point where people perceive that artifact as an extension of themselves". It is in this framing that we seek to create future pleasure objects, devices which are still devices with electronics, sensors, actuators, but which become an extension of the person, helping them to explore their bodies, and understand what pleasure means to them.

4. DIY CULTURE AND KITS TO WORK/REWORK YOUR BODY

DIY (Do-It-Yourself) cultures contain many sub-cultures. Some of these subcultures focus on the creation of kits, where you can create something following instructions, and use a set of modular elements which are provided in a kit. A simple example of this might be a DIY-craft kit, or food based, such as make your own jam, or electronics based. Examples of DIY kits exist extensively within academia, such as a DIY paper machines kit (Oh et al, 2017), a DIY circuitry kit (Kim, 2013) or a DIY silicon soft circuit kit (Nagels et al, 2018). When we conducted desktop research investigating on-market DIY kits and the body, we found that current available technologies are primarily focusing on two parameters: penetration and vibration. Users can mold various phallic shaped objects and equip them with vibrators or use existing objects such as fruit to create their own vibrators, supported by open-source device platforms such as OSSex (Comingle, 2018). While these types of kits and platform do offer a craft-like approach to constructing an artifact, we felt there was an opportunity for expansion into new domains, which are explorative rather than goal-oriented.

We were particularly interested in what a kit of electronics might contain if artists were to design one for people to facilitate their own pleasure. Electronic kits are popular, many can be found on sites such as SparkFun (Sparkfun Kits, 2018), an electronic supplier and community for people developing such kits which typically include all the tools to build a functional device. We also gained inspiration from Perner-Wilson's "Kit of no parts" (Perner-Wilson, Buechley and Satomi, 2010) wherein she introduces a set of craft materials which act as catalysts for creative exploration of material interaction without adhering to a typical "build-this" kit such as the kind found at Sparkfun. Similarly, LittleBits offers kits which offer an exploratory experience, their basic kits offer (mainly children) the opportunity to experiment with electronics, and they also offer derivative kits such as their sound/synth kit: (LittleBits Synth, 2018).

We imagine a series of DIY kits co-created with artist, offering a concept such as those presented in the section "Platform for artistic pleasure kits". We are currently developing our own kit, the *Kit Zero*: a barebones kit which offers a series of vibration motors with multiple types of input. This kit investigates what the vibrator actually is, what technological boundaries there are and how vibration can be connected to our body in new ways and represents an alternative to binary pleasure objects; with this kit, users can explore various types of vibration as output and various types of input. As an example, a person might like to explore how stroking a stone, fabric, or moving hands through water could control a vibrator. The input methods are limited only by imagination and the output can be explored, in this first phase, via 4 different styles and sizes of motors.

5. FROM SEX TOYS TO PLEASURE OBJECTS

5.1. The workshops

The workshops are based on a hacktivist, open source approach where knowledge is produced collectively. Furthermore, our project relies on feminist hacking as an art-based research practice involving an intensive knowledge-sharing process, structured around breaking with feminine gender scripts, transgressing gender norms and embracing technological challenges. Feminist hacking is about developing artistic technology, based on open hardware, from a queer and female perspective.

We wanted to work out of safe spaces; an intentional environment where knowledge exchange is encouraged among participants and where we enable learning from each other to come up with new ideas and concepts. Thus, we set up the workshops in two environments in Vienna and Copenhagen which both have an emphasis on inclusion and creating safe and creative environments.

5.2. Workshop 1: Mz* Baltazar's Lab, Vienna, 12. 2016

In this first workshop, we knew we wanted to explicitly set the challenge to design away from phallic sex toys and instead focus on bodily engagement and exploration. Together with the founders of Mz* Baltazar's Lab in Vienna, we sent an invite under the title *Future Sexual Objects* to everyone on their mailing-list. Twelve participants joined us with very different backgrounds such as medical doctors, artists, designers, hackers and people with an interest in technology and/or the body. The invite specified:

"Sex toys are often limited to being phallic in shape and having limited modes. We know there is room for improvement, but what are the possibilities for shapes and features? The overall theme of the evening will be, how can we re-invent the vibrator? The emphasis will be on discussing potential features and how various features might affect the understanding of sexuality and the relation to technology."

As we wanted to be inclusive of everyone's skills and we only had 2.5 hours at our disposal for the workshop, we did not plan for technology development, or hacking, to occur. Our aim was to investigate if people were actually interested in the subject, in sharing knowledge about the subject and if so, to start a dialogue about future joint projects

Participants were shown a presentation of images featuring different shapes, materials, technologies and ways of stimulating the body such as acupuncture and reflexology to expand their associations of bodies and technology. Following this, we held a discussion about pleasure and how participants related to technology and their bodies.

Participants exhibited surprising openness and willingness to share both what they considered problematic in relation to current technology developed for the body and ideas for potential future projects and 3 projects (described below) emerged as a result of this workshop. However, some participants indicated they would be interested in working with bodily interaction, though not sex toys. Participants were not only interested re-inventing the vibrator but rather widened the scope to encompass pleasure on a whole-body scale and expressed interest in the exploration of technology that goes beyond vaginal stimulation alone.

Workshop 1: Conclusion

As the debate focused on body and pleasure in a broader sense, the title of the project evolved to become Future Pleasure Objects. In this stream, there was significant interest in the development of DIY kits and three projects emerged from the discussions.

5.3. Workshop 2: S-rummet, Copenhagen, 02.2017

For the second workshop we decided on a different approach in regards to finding participants as we wanted to start prototyping kits. We invited our personal connections, including academics, artists, hackers, creatives and people from industry. We curated a diverse group to facilitate debate and designed the workshop using a group based approach wherein participants in groups debated amongst themselves. This was similar to a focus group (Bjørner, 2015, p. 73) but with more emphasis on casual debate and brainstorming than analysis of a product.
The workshop began with the same presentation as in Vienna, however, we changed the headline to *Future Pleasure Objects*. Afterwards we asked participants to form groups and tried to ensure there was a mix of artists, academics, hackers and others in each group. We asked groups to consider the following keywords, which were derived from the

presentation: Material, Shape, Context, Triggers through other means (light), Surfaces, Links to external events, Portable, Shape shifting, Sound, Clothing, and Sensors. Each group created a set of mind maps noting their discussion and these are briefly presented below:

Group 1: A focus on treasure maps arose, asking about how geocaching or dead-drops might be used to convey data which could be interpreted as actuated activity in a bodily device.

Group 2: There was a distinct focus on developing products with aesthetic quality and using aesthetics as a pleasure trigger.

Group 3: An interest in sound, movement and experience was dominant in this group as they explored sound versus visuals as potential sources of pleasure.

We derived a set of common themes from the groups, namely an interest in exploring unusual ways of interacting with the body including: sound, light, data, via public activity sensing, fluids, and memories. Further, two strong themes emerged, that of the difference between public and private, and interpersonal versus personal relationships. There was significant discussion about how to engage with the world outside the bedroom, including the city, other people, landscapes, and as mentioned, public activity. Further, the topic of interpersonal interaction was also strong, participants imagined how we might interact with others to create and enjoy pleasure, without those others necessarily being a sexual or highly personal relationship.

Workshop 2: Conclusion
All groups were interested in developing kits and had many ideas for future projects. We found that this second workshop further informed our work in the development of objects designed for pleasure for the individual's body.

5.4. Workshop 3: Vienna, 12.2017

We returned to Vienna to have a dialogue with the artists responsible for the three projects which emerged during the first workshop. The artists are Patricia Reis and Kristin Weissenberger. Patricia Reis is a researcher who has been researching the relation between art, technology and the body (Reis, 2018). For Future Pleasure Objects she is experimenting with breath and sensation on the body. Kristin Weissenberger works with various materials, primarily ceramics. Kristing was joined by Günter Seyfried, both from Pavillon35 (2018), and they were joined by Doris Roth from [kat]alab (2018). Together, they developed a project involving ceramics and the development of a new type of hydrogel. The three projects are described in the section: *Platform for Artistic Pleasure Kits*.

5.5. Summary of Workshops: Moving from idea development to a DIY Kit platform

The workshops informed what the DIY kits might contain in relation to materials, shapes and ways of interacting. Most interestingly was a move away from silicone as a material, the desire to experiment with other types of shapes than the phallic and penetrable shape, and to develop new social ways of interacting through technology in order to achieve pleasure. We found that the technologies developed were not aimed at women or men, but focused on non-heterosexual notion of sexuality.

As a consequence of the discussion at the last workshop in Vienna we aim to develop a platform for future pleasure objects, alongside artists and hackers, who combine electronics with other mediums, interaction modalities and our physical world to enable people to explore pleasure, and ultimately themselves, and others.

6. PLATFORM FOR ARTISTIC PLEASURE KITS: EXPLORATIONS IN WHAT FUTURE PLEASURE OBJECTS MIGHT BE.

As the three projects were being developed (described below), we begin to develop the idea of an online platform for artistic pleasure kits. This will take the form of a website whose aim is to become a platform wherein artists co-create the kits with those curious about non-binary pleasure objects.

We imagine a series of kits offering concepts such as the below described *Ardourino*, *Touching you/me with my breath* and *Text Me,* in a kit format.
The components needed to build such a device would be offered as a DIY-Kit containing the necessary elements, instructions, and importantly, suggestion to experiment and derive new experiences.

One of the first kits to be offered on this platform will be our future work, Kit Zero as described earlier in the section: DIY Culture and Kits. This website's content is owned by the artists and potential surplus is shared collectively. In this way the website becomes an experiment for future business models, where artists are recognized for being the producers of content.

The following three works are presented as beta versions of Future Pleasure Objects DIY kits:

6.1. Text Me

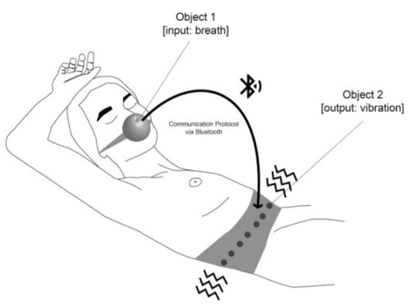
Text Me by Patricia Reis & Yara Bartel is a wearable device which does not rely on binary gender assumptions to operate. Instead, it focuses on the spine, where 12 vibration motors are triggered in varying patterns according to the content of text messages sent to the device. Reis and Bartel aim to facilitate a digital translation between body and mind, triggering body sensations via text message.

6.2. Touching you/me with my breath

Figure 1: *Text Me*

Touching you/me with my breath by Patricia Reis is an interactive, non-visual device which aims to bring people together via breath, or allow someone to explore their own sense of pleasure via their own breath. As breath is sensed, a microcontroller translates the rhythm, intensity and humidity of the breath into vibration patterns using 10 motors on an adaptive textile belt. This piece is again, genderless

Figure 2: *Touching you/me with my breath*



in nature, and seeks to subvert visuality as the primary mode of experience as it stimulates the body.

6.3. Ardourino

Ardourino by Kristin Weissenberger, Günter Seyfried from Pavillon35 & Doris Roth from [kat]alab is an environmentally sensitive hydrogel which is reactive to electromagnetism.

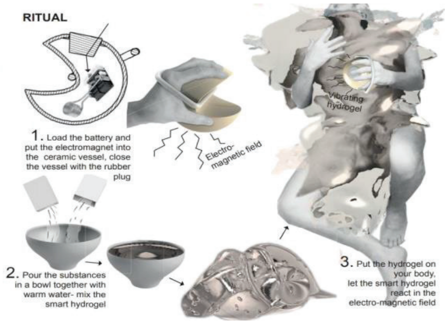


Figure 3: *Ardourino*

Ceramic vessels transfer the hydrogel on to the body, and an electromagnetic field is applied, activating the gel and creating sensations on the body.

7. Discussion

Our overall ambition is to advance the vision of the future of design, form and function of technologies designed for sex and pleasure and help mediate autonomous and non-binary articulations of desire and the machine. Entering the workshops, we came with a framing of what non-binary sex objects might be. The first workshop informed us that pleasure was much more interesting a term than sex, and extends to pleasure of the body, learning about the body, and experiencing the body. In workshop 2, we heard many ideas for how this might happen, both experiencing the body and experiencing new sensations, associations and having new experiences in new contexts.

There is an interest from artists, designers, academics, hackers, creatives and others to develop new concepts entirely about how we relate to pleasure and to our bodies. This move from sex to pleasure was of vital importance. Before we began the first workshop we had many discussions about what exactly disturbed us about this area, what needed to change. Besides our feminist and hacker approaches, we knew that sex extends beyond genital based pleasure. We developed the presentation we showed to the workshops to showcase these thought processes, asking: what other forms could pleasure take, and must it always be sexual in nature?

We see the three projects which emerged from this process and the upcoming Kit Zero as representations of the variety of forms future pleasure objects might take and we hope that the platform we develop can provide space for others to engage in this debate and create their own future pleasure objects. These kits represent, and offer an opportunity to explore how sex, or pleasure objects dictate what kind of sex we have and what sex and pleasure means to us as individuals. The kits enables users to explore their own sensitivity, to get inspired by a non-essentialist notions of gender and to tinker with a wide range of materials and technologies to extend norm-regulated (normative) body practices.

8. CONCLUSION

In this paper we document how our speculative concept of a future pleasure object emerged from three DIY workshops held in Vienna and Copenhagen. Based on these workshops our focus shifted from alternative and DIY forms of sex toys to a less genital-centered and simultaneously more sensation-based approach to bodily exploration and pleasure.

We situate our research in the feminist 3rd wave movement which fosters awareness of one's own desires, claims gender to be non-binary and embraces sexuality as part of our everyday lives.

We present three artistic works which emerged from these workshops, Text Me, Touching you/me with my breath, and Ardourino. All three reflect the discussions about the need for a deeper engagement with the participants' personal and intimate needs and desires. These three works act as beta DIY kits, alongside our presented future work: Kit Zero which provides sensors and actuators to begin forming one's own kit for exploration, will become part of an online platform, offering DIY-kits co-created with artists to help explore their own concepts and understand of pleasure.

This work acts as a starting point, inviting others to join our research and contribute to future pleasure objects.

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ACCEPTED AND AWAITING PUBLICATION PAPER 1

TOWARDS METRICS OF MEANINGFULNESS FOR TECH PRACTITIONERS

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Case Studies

Towards Metrics of Meaningfulness for Tech Practitioners

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ABSTRACT

HCI and the tech industry are increasingly interested in designing products that afford meaningful user experiences. Yet while several metrics of meaningfulness have been suggested, their utility and relevance for industry is unclear. We conducted workshops with 9 welfare technology companies and presented them with different metrics from existing literature in HCI, psychology, and industry, to evaluate their product and consider how relevant designing for meaningfulness is for them in their practice. We point to four metrics which companies considered particularly relevant, and suggest that further defining metrics of meaningfulness in HCI would be beneficial to both academia and industry.

CCS CONCEPTS

• **Human-centered computing** → **HCI design and evaluation methods**; *HCI theory, concepts and models*;

KEYWORDS

Meaningfulness, meaning, eudaimonia, user experience, welfare technology.

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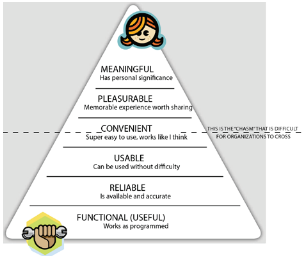

Figure 1: Meaningful UX is often considered a peak goal for Interaction Designers. Image from [1, p. 12].

Worksheet 1
Personal development: How does it contribute to a sense of identity?
Moments of significance: How does it facilitate personal transformation?
Value over function: How does it offer more than convenience?
Meaning in everyday life: How can it adapt to fit what we need in a given moment?
Critical reflection: How does it make us reflect on ourselves, our actions, and the products we are bringing into the world?

Sidebar 1: Questions based on ongoing research and derived from [3]. All 6 worksheets are included as supplementary material.

INTRODUCTION

HCI is increasingly interested in considering how technology use impacts the human experience of meaning [10, 11], as well as how to design for and foster meaningful user experiences [3, 5, 6, 14]. This interest is also shared by industry, as evidenced by Facebook's CEO Zuckerberg recently declaring their aim to prioritize "meaningful interactions" [16]. Similarly, many practitioners consider meaningful user experience (UX) the ultimate goal to aspire towards (see Figure 1). However little is known about how to consider "meaningfulness" in the design and evaluation process [9, 12]. While HCI researchers [3, 9, 14] and practitioners [15] have suggested several "metrics" of meaningfulness, their utility and relevance to industry remain unclear.

As there is no concrete consensus on what meaningfulness entails [4, 13], we explored six different metrics of meaningfulness in a series of workshops with welfare technology practitioners. These workshops fulfilled requirements for part of an ongoing research project, funded by the Danish Ministry of Higher Education and Science, who are interested in understanding what designing for meaningfulness means for welfare technology companies. This case study describes the workshops and the findings, namely that the welfare technology companies taking part in the workshops are keen to take meaningfulness into account when designing and evaluating their products. Further, we discuss the benefits and challenges inherent to the various metrics of meaningfulness and point to four metrics in particular which may benefit industry. A video featuring the companies is available here: https://youtu.be/C0RynTA-sRs

METHOD

Workshop Setup

Nine workshops were held over a period of one week. Each workshop was two hours long, and companies were presented with 6 worksheets featuring different "metrics of meaningfulness" (see next section). The workshops were attended by the CEO (or similar level person) from the company, two external consultants, who were interviewing and taking notes respectively, as well as the first author, who observed and then joined discussion after the workshop. The first author briefly presented their work in designing for meaningfulness and an overview of the worksheets. The external consultant then facilitated the workshop. Worksheets 1, 2 and 3 were presented in an interview style as these questions enabled discussion. Worksheet 4 was filled out silently to give companies a chance to pause and reflect. Worksheets 5 and 6 were presented in the form of ten-point Likert scales (as the original questions from [7, 8] were from a statistical psychology study) and companies were asked to think-aloud, presenting their rationale for their rating. Participants' comments were audio-recorded, transcribed and translated into English, before we analysed the data via affinity diagramming [2].

Worksheet 2
Coherence

- Is it clear to the user how the product connects to their life?
- Does the product make sense to the user?
- Does interacting with the product feel right?

Purpose

- Does the product help users identify personally important goals??
- Does the product help users set manageable smaller goals to reach personally important goals?
- Does the product support users in reaching and achieving those goals?

Significance

- Does the product matter to users beyond the momentary interaction? How so?

Sidebar 2: Questions based on the components of the experience of meaning [4, 13].

Metrics of Meaningfulness

To account for different facets and nuances of meaningfulness, we employed a variety of potential metrics drawn from psychological research on meaningfulness, existing metrics for industry practitioners, and our own ongoing research. These included the "mechanics of meaningfulness" ([3], see Sidebar 1); a set of questions developed by us to inquire into the experience of coherence, purpose and significance, which have been argued to constitute the defining characteristics of meaningfulness in recent psychological research ([4, 13], see Sidebar 2); the physical characteristics of meaningfulness ([3], see Sidebar 3); the meaning and purpose questions from the Better Things industry tool [15], and finally, the hedonic and eudaimonic motives for activities (HEMA) scale [8], as well as the subjective experience of meaning scale [7], as both have been previously applied to UX research [14], and have been argued to serve as potential generative questions [14].

Company Recruitment

The first author had met the companies at a health and rehabilitation trade show and invited them to participate in the workshops. Ten small to medium sized companies were invited and 9 were able to participate. Our ambition was to have a variety of companies which represented various health care products (welfare technology companies). The companies ranged from those with no technology currently present in their products (but who might consider it in the future) to those with a device. Sarita Caretech, for example, already has an interactive, hardware based product. Their product is the Sarita Pearl, a wearable, jewellery inspired personal alarm system which calls for help in case of emergency. Sarita's Chief Marketing Officer who has also contributed to the user experience design of their product attended the workshop. This company was chosen as the exemplar for their relevance to the field of HCI and quotes and anecdotes from them are used throughout this work. Alongside Sarita, we present four participant companies – who agreed to having their company names and quotes published – while exemplifying our four highlighted metrics of meaningfulness.

METRICS AND FINDINGS

Our ambition with these workshops was to explore how the companies responded to the different metrics of meaningfulness, and which of these made the most sense for them.

Worksheet 1: Mechanics of Meaningfulness (Sidebar 1). Companies were asked to select two of the Mechanics of Meaningfulness to focus on as we did not have time to go through all of them. Companies primarily chose "Value over function" and "Meaningfulness in everyday life". One chose "Moment of significance" and two chose "How does it establish personal values?". The mechanics: "Personal Development" and "Critical Reflection" received no selections from the companies, which might be a reflection of the fact that all the companies were healthcare based. It should also be noted that for most companies, three types of users were identified: the citizen, the caregiver and the municipality. The products typically helped to save the municipality money, helped the caregiver to do their job, and helped provide a better quality of life for the citizen. From this worksheet, we present below two examples of how the companies responded to these metrics:

Meaningfulness in the everyday: Zibo Athene makes a weighted vest for inducing Oxytocin and calmness. Their product is typically used before people leave the house to enter society and go to work or be social. They explain "this can make a big difference for an individual which wants to set small goals such as participate and function in the everyday."

Value over function: DEMOS10 by Brane is a tool to monitor patients with dementia who might have sleeping problems. They explain how the data is the function, but the value is in the insight: "the personal transformation exists in the insight". The data provided highlights when a person with dementia has, for example, been wandering, lost after going to the restroom during the night, and with the insights provided by the data, caretakers can "feel secure in their decision based on objective data instead of subjective observation".

Worksheet 3
Non-screen: If the product has a screen, why does it need this?
Tangible: What are the physical characteristics of holding and engaging with this object?
Everyday: Do we use it every day or only once in a while?
Craft: How does this relate to traditional craft?

Sidebar 3: Physical characteristics of meaningfulness [3].

Worksheet 2: Components of the Experience of Meaning (Sidebar 2). Companies typically focused on one user group (care taker, citizen or municipality) for 'personal goals' and then considered the overall significance to all user groups. Sarita explained how for the elderly, "if they have a stable everyday life, then maybe that's their goal, keep the status quo" and elaborated: "The meaning was different for each group. For elderly it's their extra ears and brain if anything happens. They can rely on it to call for help. For the caregiver, they could take precautions and protect the elderly."

Purpose (personal goals): For Boblberg – an online platform for social gathering, the user decides which goals are important for them, for example, someone with social anxiety might want to go for a walk outdoors with someone else, but not necessarily go into the city or meet with other people. Through the Boblberg platform, they can find someone to do this activity with and as Boblberg explains, "everyone has a right to be part of a community. Through a larger focus on togetherness and people, we can improve the health of society."

Significance (more than momentary interaction): HopSpots is a company creating programmable discs which children can jump on and interact with via light and sound. They explain how HopSpots allows people to realize their impact on the world around them, namely, how users "got an 'ah-ha' experience and pride about how it was them who had made this". Further, " actually being able to do this themselves (which) gives a personal transformation"

Worksheet 3: Physical Characteristics of Meaningfulness (Sidebar 3). This worksheet focused on four qualities: non-screen, tangible, everyday and craft which emerge from a larger research study currently being conducted (see [3] for preliminary findings). All companies but one had non-screen products (one was an online portal), and all were tangible in some way. Each felt that they strongly resonated with the concept of something 'everyday' as people need to use the products on a daily basis and few considered traditional craft, as most were designed for medical industrial standards for cleaning and durability. Sarita described how they worked with jewellery designers to create something beautiful that the elderly would accept and wear on a daily basis, and designed it to be an individualized gift. "We designed the opening experience... When the nurse comes with it and says "Eva, this is for you, this is the design you chose" then Eva should say "Oh it's mine, nice". And then it's her individual one." The meaningfulness present is for the citizen in terms of the significance of having something which is personalized and which keeps them safe. As Sarita explained, "If the product is not valuable for the end user then they will not use it and it will be another product in a drawer."

Worksheet 4: Better Things – Purpose and Meaning Questions. Companies were asked to silently write their answers and ask for clarification if they needed it. Many of them had trouble answering some of the more abstract questions such as "is it art?" or "how does it provide beauty to your life?". For many of the questions, they simply filled in their product pitch, such as how it solves a problem but for these more abstract questions, many companies stated "these are good questions, they are making me think in different ways, but I don't know how to answer it." Sarita answered the question, "How does it create a sense of wonder?" with "Its intelligence - 'hidden technology' in a piece of jewellery". While these questions did result in some interesting answers such as this one, it was most interesting that 4/9 companies chose not to answer "how does it make me a better person?" which we see as contributing to the lack of consideration about meaningfulness in the product in terms of purpose, significance, personal development or value over function.

Worksheets 5 and 6: HEMA and Subjective Experience of Meaning Scales. Companies were eager to discuss their rationale for the rating they gave their products, but overall, were confused by the similarity of the terms presented by Huta and Ryan [8], and Huta [7]. Many companies had problems differentiating, for example, between something 'dear' to me, something which I 'treasure', or something which is 'precious'. The same confusion arose from 'seeking relaxation' and 'seeking to take it easy' or the nuanced difference between 'playing an important role in some broader picture' versus 'I could see where they fit into the bigger picture'.

Summary of Findings

Companies seemed to give the most in-depth answers to worksheets 1 and 2. Sarita reflected on how the Pearl contributed to purpose and value over function: "The product has one function... the microphone and loudspeaker. It creates the value of feeling close to the caregivers who surround you and protect you in emergencies... The whole human to human value is pretty important." Here they specify the function, and then focus on the value. Sarita explained: "the core functionality is an alarm. It's for an emergency. The main functionality is: where are you, did you fall or not, did you push your button or not? You can also detect if it is on the body or not. The whole package helps create these bigger goals." This answer indicates how the questions about meaningfulness and eudaimonia may promote more careful differentiation of a product's function and value, as well as encourage reflection on what is most relevant for the users. Other companies similarly answered in detail, both providing their product pitch and then digging deeper, looking to what really matters for their users.

The Better Things questions acted to provoke critical reflection, but ultimately the companies did not provide much more than their product pitch. The HEMA and subjective experience of meaning scales were deemed confusing in terms of language and the nuances between terms, but did provide some opportunity for critical reflection, such as when companies challenged themselves, for example "Put it as a five, in the middle ground, as it's a very fluffy term, and it's not really proven yet that our product would be able to do so, for the end user".

Feedback about the workshops demonstrated the relevance for companies: "It was a great pleasure and I look forward to hear what the future brings when meaningful design is a part of product development", "Thank you for some great hours, reflective thinking and good feedback on our product", and "It was really interesting, we certainly got some tools we can use moving forward". Further, it should be highlighted that companies dedicated their own time and resources, signing off on a minimum of 10 hours used (transport, preparation, workshop and aftermath). Together with the present work having been financed by the Health and Welfare Technology network in Denmark, this speaks to the relevance and importance for designing for meaningfulness for industry and the need to establish standardized measures to evaluate meaningfulness in upcoming or established products and services.

DISCUSSION

Companies were clearly interested in the concept of designing for meaningfulness, indicated both by the companies' time investment in the workshops and via the positive feedback provided. In this light, it is important to determine what appropriate metrics of meaningfulness are, and how to evaluate these. In this work, we have presented six different ways of evaluating potential metrics and find that companies responded most thoughtfully and critically to four metrics in particular: *meaningfulness in the everyday*, *value over function*, *purpose* (personal goals) and *significance* (beyond momentary interaction).

These workshops indicated to us that companies all believe that their products are meaningful, however it is in the nuances where the quality metrics of meaningfulness emerge and can be further evaluated. We suggest that these four metrics act as a starting point for researchers to begin exploring aspects of designing for meaningfulness in industry, and suggest that the other metrics are further evaluated to determine in which contexts they might be relevant. When asked if they thought the metrics of meaningfulness might be a viable service to offer industry in the future, Brane, who has over 30 years experience in consultancy, said: "I think it is undervalued - these things, to use money on these. I think it is difficult to sell but I really think it's valuable. It's a good way to to do it, to come at it from these different angles and to refine it."

Both from our discussions with companies and discussions with industry, we anticipate that these metrics of meaningfulness may primarily serve companies in the ideation and evaluation phases of product development. In the ideation phase, they may use it to ask why they are building this product or service, for whom it is intended, and what impact that will have on the stakeholders from an aspect of designing for meaningfulness. In the evaluation phase, companies may consider employing these metrics to assess end users' experience with the product or service and adapt it as needed.

Limitations and Considerations

In these workshops, we focused on how specifically Welfare Technology companies might use metrics of meaningfulness to evaluate their product or service. Future work is necessary to assess whether these metrics readily generalize to other technologies and domains.

Moreover, it became apparent that just asking whether a product was considered 'meaningful' as per Huta's Meaningfulness scale [8] was not sufficient: Most companies gave their products the highest rating. However, when they discussed the nuances of how their product was meaningful, such as in regards to meaningfulness in the everyday, value over function, purpose or significance, then it was necessary to consider how their product related to each of these aspects.

Finally, the format of the worksheets impacted how companies answered questions. Generally, interviews (worksheets 1, 2 and 3) allowed for more discussion, quiet reflection and writing (worksheet 4) allowed for shorter answers, and talk-aloud Likert scales (worksheets 5 and 6) allowed for conversation, but less in-depth than interviews. Also, language should be taken into consideration as the interviews were primarily conducted in Danish with the exception of two companies who preferred English.

CONCLUSION

We explore the potential of six metrics of meaningfulness for welfare technology practitioners. We found that providing a more nuanced and multi-faceted account of meaningfulness as presented via our worksheets, helped practitioners critically reflect and debate about their product. We point to four metrics in particular which companies responded most thoroughly to: meaningfulness in the everyday, value over function, purpose (personal goals) and significance (more than momentary interaction). We suggest that future work looking at the metrics of meaningfulness explore these terms further and expand to evaluate more than welfare technology companies.

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SUBMITTED PAPER 1

MUSCLE MINDER: A HAPTIC CUE SYSTEM FOR EXERCISE

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Late-Breaking Work

Muscle Minder: A haptic cue system for exercise

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ABSTRACT

HCI and the tech industry are increasingly interested in designing products that afford meaningful user experiences. Yet while several metrics of meaningfulness have been suggested, their utility and relevance for industry is unclear. We conducted workshops with 9 welfare technology companies and presented them with different metrics from existing literature in HCI, psychology, and industry, to evaluate their product and consider how relevant designing for meaningfulness is for them in their practice. We point to four metrics which companies considered particularly relevant, and suggest that further defining metrics of meaningfulness in HCI would be beneficial to both academia and industry.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**; *Interface design prototyping*;

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KEYWORDS

Haptics, Cueing, Mind-Muscle, Exercise, Non-Screen

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INTRODUCTION

Within Interaction Design, there is an increasing focus on both research into haptics [9, 13, 23], and exercise [12, 18], with a focus on rehabilitative technologies [5]. Much of this research is concerned with prompting and guiding corrective muscle movement. Research in sports physiology looks to focus [4] as a factor in effective exercise, and we situate our work within the meeting of these two domains: assistive, interactive technologies which might facilitate better focus (or mindfulness) during exercise with specific focus on a mind-muscle connection.

METHOD

We situate our work within research through design [7], utilizing early sketches [3] which generate knowledge and help us to develop an understanding of the problem domain and possible solutions.

In this work, we are in an "active process of ideating, iterating, and critiquing potential solutions" [24] and this process as a work in progress, explores potential technologies and applications of those technologies. In this first iteration, we focus on the technology and users' reactions to the sensation of the haptic squeeze, using the feedback gained and knowledge derived from working with this early sketch to inform our future work.

RELATED WORKS: MIND MUSCLE CONNECTION AND EMG SIGNAL

In this related works section, we give a brief overview of work done in two areas: first, within mind-muscle connection and second, within technology enabled tactile feedback to improve physical activities.

Mind-muscle connection

Research indicates the act of focusing on a muscle group has significant impact in terms of muscle activation or muscle fibre recruitment. Studies on the effects of focus during resistance training demonstrate a 20-60 percent increase in EMG signal when mental focus is on a particular muscle group. [4]

Mental training was shown to lead to higher activation of muscles [21]. In presenting "attentional focus", Schoenfeld and Contreras [22] describe internal focus of attention, focusing on the muscle

Figure 1: The MyoWare Sensor mounted on the bicep in the appropriate location according to [1].

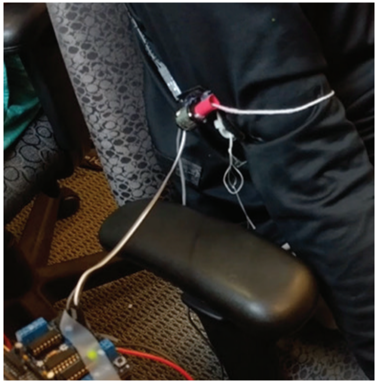

Figure 2: The twisted actuator mounted on a shirt.

in terms of bodily engagement during an exercise and points to the occurrence of greater muscle activation when "subjects were instructed to adopt an internal focus of attention". During these studies, participants had been asked to focus on the muscle group and instructed to do a particular exercise, however the cueing was only verbal. While acknowledging the extensive area of embodiment and phenomenology [16], we focus our work-in-progress on bodily experience within HCI and look to how cueing of bodily engagement has been explored in terms of tactile feedback on the body

Tactile Feedback

The use of tactile feedback in textiles and HCI is extensive, from applications in music [17] to virtual reality [2] to various forms of tangible interaction in wearables [6, 11, 19]. Within our scope, one example is [8] who demonstrated a system to correct posture using vibrotacticle feedback. Using vibration actuators to stimulate somatosensory perception (the sense of where the body is in space), they found that participants found the vibrotactile feedback to be "simple and easy to comprehend" and that the small form factor of the vibrotactile system did not interfere with the "natural reaction of subjects". In looking at the effective placement of haptic wearable systems, [15] point to the "wrists, upper arms, outer thighs, feet, chest, stomach, and spine" as being most practical for wearable applications, but highlight the wrist, spine and then arms as most preferred for detecting vibration. In our initial study, we focus on the upper arm coupled with a strong squeeze to gain mental focus on that area.

HAPTIC FEEDBACK

We were interested in how vibrotactile feedback might help the user to focus on their muscle, choosing to focus on an embodied experience involving a squeeze. Vibrotactile feedback can be intrusive [10] and we were particularly interested in generating a more active haptic cue, using a squeeze that feels less like a notification and more like a trainer's hand on the arm to guide the mind towards that muscle group. [20] similarly looked to compression for notifications and we extend this to evaluate the use of twisted actuators, a string which tightens via a motor, effectively squeezing the participant's arm.

TECHNICAL SETUP

Using an exercise shirt as a base, we attached a small servo motor using a twisted actuator setup [14] wherein a string was attached to a motor. When the motor turned, the string was pulled tight. See Figure 2.

A MyoWare Muscle Sensor kit was used to measure the EMG of the user. The MyoWare electrodes were placed on the user's arm "between the muscle endplate region and the distal tendon insertion" as according to [1] this placement gives the highest signal values. See Figure 1. We set up the kit

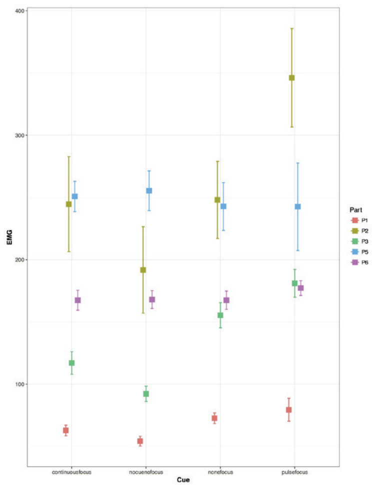

Figure 3: Having people focus on their muscles and providing them with a cue before each movement showed higher average EMG activation compared to continuous cueing or no cue.

according to the instructions on Sparkfun and adjusted the gain to give the best average signal across multiple body types by trying it with 4 different people of varying height, weight and muscular makeup.

ENCOUNTERS

An initial exploration into how the squeeze might facilitate a stronger mind-muscle connection was designed. Our aim was to compare squeezing cues versus no cues (no activity) to determine if the squeeze made any difference in the EMG output. As this was an initial exploration, we tried to include participants of varying height, weight and muscular density.

We presented participants with 3 interaction cases:

- No cue
- A pulse (repeated squeeze or tightening of the string)
- A continuous squeeze (tightening of the string)

There were two possible focus cases wherein focus means to concentrate mentally on the muscle being exercised, in this case, the bicep:

- No focus (no instruction given to focus on muscle)
- Focus (instruction given to focus on muscle)

We first obtained a baseline of data, determining the EMG signal with no activity, with a bicep curl, and then with focusing on the muscle and doing a bicep curl. To reduce bias, we randomized the test order.

PROCEDURE

Our procedure included the following steps for each participant:

- Attach the EMG Sensor to the bicep
- Put the exercise shirt on over the EMG sensor
- Get a baseline reading
- Ask the participant to focus on their bicep
- Focus in 3 ways: no cue, pulse and continuous (these were randomized)
- Get a baseline reading

RESULTS

From our initial encounter with the sketch, we were able to determine that having people focus on their muscles and providing them with a cue before each movement showed higher average EMG activation compared to continuous cueing or no cue. See Figure 3.

INTERVIEWS

After experiencing the squeeze interaction and moving through the test phases, participants were asked a series of questions about their impression of the squeeze as a mind-muscle enabling cue, and their preferences. There was an equal split: with three preferring the squeeze and three for the pulse. One who preferred the pulse suggested that they could "use this for setting a pace and then I don't have to worry about keeping up a rhythm" [P4] and one who preferred the squeeze stated, "[the sensation] feels good as a reminder that my muscle is working" [P1].

DISCUSSION

In our initial explorations, we gained insights about how we could use a non-vibrational haptic cue to facilitate a mind-muscle connection. This initial work points to openings for further research, and opportunities to design for problems which presented themselves during the encounters. One example of this would be to design for the case in which the user loses focus during the exercise as their initial focus might be strong but upon doing more repetitions, they lose focus. In this case, we might explore if sending small reminder cues when the user's EMG signal goes below a certain range, helps them to regain focus. Further, we might be able to see trends of when EMG signal is beginning to fall and then design something to help users to stay focused and above a certain EMG threshold throughout their exercise.

One major question which arose during this initial work was, "How does one decide when attention is happening?". In this case, we simply asked participants to focus on their muscles but it could be interesting to look to EEG signals in combination with EMG measurement to see the effects of focus. This would depend on many factors with the EEG measurement and how accurate the reading is and what could be derived from it. In future work, we would be particularly interested in comparing more cues such as rubbing, stroking, pressing or poking as methods to cue mind-muscle focus and which of these might be most effective.

CONCLUSION

This late-breaking work helped us to explore a design space of using subtle, non-visual, haptic cues to develop mind-muscle connections. We demonstrate that the existence of such cues indeed improve EMG activation, opening the door for future examinations into the efficacy of different types of cues on various rehabilitative and muscle strengthening exercises.

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SUBMITTED PAPER 2

TRÆKVEJRET: A KINETIC DEVICE ENCOURAGING BODILY REFLECTION

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Trækvejret: A kinetic device encouraging bodily reflection.

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Abstract
A flexible wooden device, “Trækvejret” which emulates a slow rate of breathing is placed in a coffee break room. This work examines related works on reflection, triggering reflection, and breathing and biofeedback technologies. We demonstrate how simple technology such as Trækvejret, which does not measure or give feedback about a user’s breathing can nonetheless potentially be useful and provoking, encouraging reflection and potentially, behaviour change.

Author Keywords
Breathing; bodily awareness; serendipitous discovery; kinetic; wellness; offline.

ACM Classification Keywords
H.5.2. User Interfaces: Prototyping, Theory and methods, User-centered design: Miscellaneous.

Introduction
We developed an artefact to explore how opportunities for momentary bodily reflection as part of everyday activities might be created - in this case, as part of the daily routine of getting a cup of coffee at work. Trækvejret (Danish for `Breathe') is a device situated in a coffee break room, which people can choose to engage with, when and if they happen upon it. A video of Trækvejret can be seen here: https://youtu.be/e_dx-aC0IXc

Figure 1: Trækvejret from front, in use, and from the side.

This a conceptual work in progress which does not present a mature study but utilizes research through design as a method to generate insights which contribute to the introduction of a design goal and which opens for debate and engagement.

Serendipitous Discovery
Ambient displays act as dispensers of non-critical information whose aim is to provide information without overly distracting the observer [22]. In this work, we see the value of serendipitous discovery as creating an opportunity to engage a person momentarily.

Motivation: Non-quantified reflection
We are especially interested in the role of physicality in bodily sense-making [6] and creation of technology (in a semi-public space) which has a low threshold for initial engagement. Further, this engagement happens without providing personalized feedback via insights, app-notifications, or reports. We focus on in-the-moment engagement with a device which requires the user to evaluate their own situation and draw their own conclusions.

Trækvejret
Trækvejret is a small wooden device which emulates breathing by moving inwards and outwards, shape shifting from a straight board, to a rounded board. See Figure 1. We present how Trækvejret was designed and built in the sections "Design Rationale" and "Process". A scenario:

A person at work feels it's time for a cup of coffee and walks to the coffee break room. They put their cup in the coffee machine and as they wait for their beverage, they discover a small wooden object moving beside the machine. They are curious about it and regard it for a moment, before realizing it is imitating breathing. They sync their breathing to the device, taking a few slow, deep breaths.

Related Works
To frame this work, we explore related works about ad-hoc, opportunistic and unexpected experiences as well as the area of reflection in everyday life.

Bodily reflection in the everyday
We are particularly interested in ad-hoc reflection, without an intention to reflect, but rather, coming upon an unexpected opportunity and being invited to engage in it. In their work, "Reflecting on Reflection - Framing a Design Landscape", Fleck and Fitzpatrick [7] describe how technology can help with reflection and encourage designers to ask "What reflective behaviours do you want to encourage? Which technologies and techniques can support these behaviours?"

In this work, we want to encourage a bodily reflection, a focusing on, and scanning of the body [26] to foster reflection about breathing and pause in the everyday. The focus on everyday reflection is also being explored in recent works in HCI, namely by Mols et al. [24] who recommend that designers should consider the "the timing of reflection, the balance of system and user initiative and the preferred social context" and by Prpa et al in exploring virtual environments and awareness of breathing [27]. We aim to address Mols et al's recommendations by situating the opportunity for reflection in a place where people choose to go to take pause in their day, and by considering the level of user initiative (the user can choose to engage with

Trækvejret, or not) and setting the social context as a semi-public space.

Bumping into technology
By placing an object in a physical space, the object becomes a persistent part of our reality in that space and one can choose to recognize or interact with it. In the case of Morse Things, Wakkery et al. [34] inquire about our relationship to things in our world, explaining that "designed digital artifacts, or in our case things, manifest technologies and directly influence the mediation of our experiences and practices".

Creating objects which exist in our world, but do not demand attention, or require attention to function is explored in other works, such as with calm [35] or slow technology [12]. Grosse-Hering et al. describe how one design principle of Slow Design, "Reveal" might be revised to "Creating awareness, uncover the function and essence of a product" [11].

We aim to create awareness of the body [27] and to uncover the essence of slowness, of taking a deep, slow breath. This emphasizes how we can use unexpected discovery and encounters with physical objects to create a trigger for reflection [25] in a slow technology way.

Awareness of breathing
For athletes [17], mindfulness practitioners [28] and those seeking to reduce their stress levels, breathing becomes something to pay attention to, to change for their purposes and to enhance their lives and practices [33]. There are increasingly more devices and apps being developed to help people train themselves in various breathing techniques. A brief overview of these is presented here. Wearables which encourage or guide mindful breathing include the Apple watch [16] or FitBit's Charge 2 [23] combining haptic feedback and visualizations to encourage wearers to take deep breaths throughout their day. There are also stand-alone apps which use visualization on a phone app [1, 2] to guide meditation, but still require the user to look at their phone screen and possibly be interrupted and distracted by other notifications [10].

Small non-watch wearables are being introduced, such as Spire [29] a device to track your breathing and give you insights about it. Breath-Minder [3] provides alarms via vibration, reminding you to breathe deeply. Vitali, a smart fitness bra [32] measures HRV (Heart Rate Variability) and breathing and provides cues to breathe deeply to reduce stress. Breathing Friend [21] uses haptics to stimulate breathing and Breathing Light [30] uses somaesthetics via light and sound. BrightBeat [10] uses subtle indicators in the form of sound, visual and temperature cues to influence slower breathing. One of our ambitions is to move from on-body cues (such as BrightBeat, the Apple Watch or Fitbit Charge 2 or Spire) to off-body, subtle, in-context cues such as Trækvejret, which is in the environment but does not demand attention. Rather, it invites engagement from afar.

In nearly all of the above mentioned examples, measurement of the user's breathing and feedback is provided. Each requires a decision to use an app, use a wearable, or use a device to consciously take time to monitor and train for mindful breathing. We are instead interested in how we can explore how placing a physical object (Trækvejret) in a commonly accessed place can

Figure 2: Questions asked after second encounter.

Interviewees were asked the following questions:

- Did you notice the device in the coffee machine this morning / afternoon?
- What did you think when you saw it?
- What do you think it is for?
- What impact did it have on you?
- Did you think about breathing later in the day?
- Do you usually think about your breathing when you are working?

facilitate ad-hoc situated serendipitous discovery leading to spontaneous bodily reflection.

Method

Throughout this study, we recall and use Buxton's sketches, a process filled with ambiguity [4] giving us the opportunity to discover, define and unfold an emerging design space.

Research through design allows us engage in ”exploring and speculating, particularising and diversifying” [9] a design situation. We generate intermediate level knowledge [15, 19] which is not a theory, but rather, generates ”knowledge that plays a direct role in the creation of new designs” [19]. Trækvejret is not intended to become a product on the market, it is rather an exploratory probe, helping us elicit qualities of a design goal.

Design rationale

In line with our method we engaged with the particularities of the design situation including the chosen space, the choice of materials, and the opposing qualities of engagement with the artefact.

The coffee break room

Before setting up Trækvejret, we saw that many individuals getting a cup of coffee pull out their phone and glance at notifications. We chose the setting of the coffee break room because it is a place of interlude. The people accessing the coffee break room spend a brief amount of time there, and so there exists potential to engage them momentarily without undue interference in their daily routine.

Material choices

We deliberately chose wood as it is both a natural material, representing nature, life, and warmth, and also it stands out amongst the plastic and steel of the coffee machine and sink.

Opposing qualities

Trækvejret does not measure the observer's rate of breathing, nor does it provide feedback. The movement of the device, the breathing, in and out, represents the average, slow rate of human breathing [5]. However, the rate of breathing is only communicated to the person engaging with the system via observation.

We asked ourselves about the opposing qualities of the artefact: how we might create an object which was non-connected, displaying information but not collecting it, allowing for engagement but not engaging itself, and encouraging behaviour change, but not demanding it?

Process

Brainstorming process

In designing Trækvejret, a brainstorming and selection process took place wherein the authors took the context of a coffee break room, and tried to imagine how we might facilitate an opportunity for bodily reflection during the process of getting a coffee.

Our aim was to generate as quickly and simply as possible, an early artefact that we could immediately make available to encounter in context. We describe this below, in “Trækvejret: artefact building”.

Figure 3:
Participants on how they have considered their daily breathing practices:

“I have predilection for gadgets and happenings but just the fact the something was there caught my attention. I think it looked very dynamic because it moved, which made me read the text”, P6

“If it just stands there, you wouldn’t look at it all the time”, P4.

”I normally don't think about my breathing but because I saw it I did”, P4

“I think it is a good idea because it moves instead of just writing “Breathe”, then you don’t do it”, P8.

“When you look at it you cannot help breathing” P4

“I think that the motion up and down aspires to a calm and deep breathing”, P2

Trækvejret artefact: Building
Trækvejret consists of a servo motor attached to a piece of laser cut medium-density fibreboard (MDF) which has been cut using a kerf bending pattern, that is, cutting through a piece of material in a geometric pattern to allow it to be flexible without segmenting it into more than one piece. The flexible piece of MDF is attached to a stand, which was laser cut for the purpose of holding the servo motor and the flexible piece in place.

Our concept for the moving material was inspired by a piece of kerf bent MDF in the lab which we picked up and began to bend as we tried to demonstrate what we had been envisioning. We asked ‘what if it looked like this?’ ‘Might this look like someone breathing?’ ‘It would be easy enough to attach a servo motor here, let’s try it.’. This approach is a way of sketching [4], exploring materials and function iteratively.

An Arduino board is mounted on the back of the stand, and the servo motor is attached to the Arduino board. A small arm extends from the servo motor and attaches to the flexible piece, moving it up and down. The Arduino has been programmed using the ‘Sweep’ example from Arduino’s servo library of examples, to move the servo at a normal rate of human breathing [5] namely, 12 breaths per minute. The servo moves, pauses, moves again and pauses, to demonstrate inhalation, pause, exhalation and pause.

Encountering Trækvejret
We conducted two small explorations to look for early indications of how we might enable bodily reflection via serendipitous discovery.

First encounter
People, upon entering the coffee room, would place their coffee cup in the machine, stare at Trækvejret and then leave the room after their coffee was made. Many who had been observed getting their coffee near it said they hadn’t known it was something they should engage with. In the second study, spanning two days, we placed a small sign above the device, which said simply ‘Trækvejret’ or ‘Breathe’ in Danish.

Second encounter
The second exploration took place over two days at four new sites: four different break rooms with coffee machines throughout the building for a duration of one hour per site. These were different break rooms from the first encounter and as people tend to frequent the same break room, our aim was that these would be people who had not previously encountered Trækvejret. We attached the instructional sign to the device, ‘Trækvejret’ or ‘Breathe’ in Danish. Following the observations, 10 verbal interviews of approximately 5 minutes each were conducted in the afternoon (to give people time to think about the experience). The interviewees were randomly selected among the people passing by the device. Questions can be read in Figure 2 and some key responses in Figure 3.

Discussion: A Design Goal
A non-connected, non-quantified device
Trækvejret communicates information about how to breathe at a slow pace, but otherwise is not measuring or sensing anything, or giving any kind of feedback. In some ways, it can be considered a display, a non-connected element of the physical environment. It differs in this way from many of the IoT or smart products that are emerging today, both in research and

on the market. As Hartzog and Selinger explain, ‘A chip-centric mentality has taken over, one that is guided by an overly simplistic principle: ‘Internet connectivity makes good objects great” [13]. By not being connected, Trækvejret was immediately accessible, requiring no set up, calibration, or instructions besides the one word ’breathe’.

Further, people who engaged with Trækvejret did so of their own accord, due to their own curiosity, and not because it promised health improvements, quantified-self reports, or other benefits. It was an interaction of opportunity. We suggest that perhaps moving away from connectivity, for some devices, might be an interesting design goal to explore.

The design goal: designing devices which encourage reflection and action rather than being data-driven
We propose the definition of this goal as being one wherein research through design is a method to propose sketches featuring simple, non-connected devices for the betterment of the self, preferably in a combination of physical and psychological aspects. In this space, the interaction is not data-driven or data-collecting but rather is passive, and potentially as beneficial through encouraging people to explore their own abilities and act upon those explorations.

Current limitations of this design space.
Firstly, we aim to avoid decorative items. By having non-connected, tangible objects which may offer serendipitous discovery, we do not include objects designed to be decorative. Instead, we point towards objects with a clearly designed intention, such as Trækvejret, encouraging people to stop and breathe, and learn to take a breath throughout their day.

In a time where privacy [8] and questions about how much time we are spending online [31, 14] and with our devices [18], we think a focus on designing for non-connected, personal development devices will be of importance.

Future Work
Trækvejret is part of a series of design artefacts being developed to explore non-screen, tangible and physical devices, and something we call Designing for Meaningfulness. We hope to expand this research in collaboration with other researchers and industry.

Conclusion
We built Trækvejret, a simple artefact which emulates a slow human rate of breathing to act as a vehicle for research into openings in design where we might invite researchers to explore how we might design for serendipitous discovery and spontaneous bodily reflection.

From our observations over two encounters with the artefact, we learned that Trækvejret elicits curiosity: people briefly engaged with it and thought about their breathing patterns and practices. We invite discussion about a design goal of designing for non-connected artefacts which can potentially be beneficial for bodily reflection and action.

We conclude that Trækvejret is a preliminary success as a research vehicle because it produced openings in design, demonstrating how something which is unexpected and simple in its design and function, promotes curiosity spontaneous engagement, and bodily reflection.

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SUMMARY

As new smart products materialize and our lives become more convenient with fitness trackers, automated lighting, and internet enabled hair brushes, there emerges a need to critically reflect on the products we are designing.

This study asks how we might create smart products which enable the following links: people-to-people, a person to their sense-of-self and a person to a sense-of-time.

In the role of Technology Experience Designer at IdemoLab, FORCE Technology, Vanessa Julia Carpenter works with Danish design companies, welfare technology companies, and those developing new smart products. Vanessa creates seven prototypes to explore values of meaningfulness which she calls the “Mechanics of Meaningfulness” and the physical characteristics, the “Manifestations of Meaningfulness”.

This study contributes an explicit definition of meaningfulness to design research and investigates and the relevant related work in academia and industry. This work aims to provide a platform upon which future researchers and practitioners may begin to define some Metrics of Meaningfulness and eventually offer a standardized tool which can be used in ideation and evaluation of future smart products.

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