

THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Defamiliarising Everyday Things

Rethinking The Materiality of Tables through Design Remakes

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Gothenburg, Sweden, 2024

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Abstract

We are surrounded by everyday things – ordinary, unassuming, and deeply familiar. Tables, for example, quietly anchor our lives, holding our mugs, hosting dinner parties, or providing a quiet space for work. Yet, their familiarity often fades into the background, taken for granted and unnoticed. As everyday things become increasingly computational, their materiality changes – blending the physical with the digital. This thesis examines how tables, as a case study, can be defamiliarised through practice-based design research to disrupt habitual interactions, provoke critical reflection, and inspire new possibilities for design and meaning-making through actuation and immaterial materials.

Grounded in two research questions, this work investigates (1) how everyday things can be remade through defamiliarisation and (2) what lessons are learned from changing the materiality of tables. Across four papers, the thesis reviews current actuated table designs, explores shadows as a design material, and presents a series of counterfactual artifacts culminating in *the Undertable*: an actuated table that provides an excuse for the playful exploration of bare-skin touch between people. By balancing familiarity and strangeness, *The Undertable* transforms a seemingly mundane table into a social mediator, inviting reflection on the meaning of touch.

This thesis proposes generative strategies for defamiliarisation and positions design remakes as a methodological contribution to design research. Future directions include formalising methods for defamiliarising everyday things, exploring actuation's potential for accessibility, design explorations of tables that grow with people over time, and revisiting frameworks of materiality to encompass computational, immaterial, and living materials.

Keywords

Defamiliarisation, Materiality, Design Remake, Actuated Tables, Everyday Things, Design Research

List of Publications

Appended publications

This thesis is based on the following publications:

- [**Paper I**] **S. Hendriks**, M. Heron, M. Obaid (Sept, 2023), *Tables Got Moves: A Review on Actuated Table Designs*
Proceedings of the 2nd International Conference of the ACM Greek SIG-CHI Chapter (pp. 1-10).
- [**Paper II**] M. Gamboa, **S. Hendriks** (Jul, 2024), *In Praise of Shadows: Sensibility and Somaesthetic Appreciation for Shadows in Interaction Design*
Proceedings of the 2024 ACM Designing Interactive Systems Conference (pp. 3272-3286).
- [**Paper III**] **S. Hendriks**, M. Gamboa, M. Obaid (Jul, 2024), *The Undertable: A Design Remake of the Mediated Body*
Proceedings of the 2024 ACM Designing Interactive Systems Conference (pp. 2591-2610). (*Best-paper Award*)
- [**Paper IV**] **S. Hendriks**, B. Hasanen, N. Afzal, I. Hussain, M. Obaid (Aug, 2024), *Enhancing Functional and Extra Motor Abilities: A Focus Group Study on the Re-Design of an Extra-Robotic Finger*
2024 33rd IEEE International Conference on Robot and Human Interactive Communication (ROMAN) (pp. 667-673).

Other publications

The following publications, in chronological order, were published during my PhD studies. However, they are not appended to this thesis, due to contents overlapping that of appended publications or contents not related to the thesis.

- [a] M. Gamboa, M.A. Baytaş, **S. Hendriks**, S. Ljungblad (Feb, 2023), *Wisp: Drones as Companions for Breathing*
Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction, (pp. 1-16).
- [b] J. Herben, E.H. Möller, J. Penner, K. Pham, M. Viklund, **S. Hendriks**, M. Obaid (Mar, 2023), *An Expressive Robotic Table to Enhance Social Interactions*
Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (pp. 151-155).
- [c] A. Cabrio, N. Hashmati, P. Rabia, L. Tumma, H. Wörnberg, **S. Hendriks**, M. Obaid (Mar, 2023), *HighLight: Towards an Ambient Robotic Table as a Social Enabler*
Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (pp. 146-150).
- [d] D. Boskovic, I.E. Tankred, Q. Ma, A.C. Zois, **S. Hendriks**, M. Obaid (Jun, 2024), *Prototyping An Interactive Ambient Plant for Meditation*
Proceedings of the 2024 International Conference on Advanced Visual Interfaces (pp. 1-3).
- [e] E. Ahlqvist, A. Machado, A. Li, P. Palmberg, L. Tholén, **S. Hendriks**, M. Obaid (Jun, 2024), *HoneyPot: Connecting Through a Mediated Ambient Plant*
Proceedings of the 2024 International Conference on Advanced Visual Interfaces (pp. 1-3).
- [f] D. Hagberg, N. Saoulidis, M. Gamboa, **S. Hendriks** (Jul, 2024), *Prototyping Playful Touch with a Sound-Mediating Table*
Companion Publication of the 2024 ACM Designing Interactive Systems Conference (pp. 309-313).

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Part I

Summary

Chapter 1

Introduction

We are surrounded by things. Over time, as we get used to them, they slowly start to disappear in the periphery of our attention. Yet, they still play an active role in shaping our lives. We develop routines and stop experiencing them. We get used to relationships and stop appreciating them. Similarly, we get used to everyday things and stop noticing them. Once we break the habitual – we defamiliarise the familiar – stirring up old patterns and make space for fresh perspectives to emerge.

One example of an everyday thing we take for granted is a table. Arguably one of the most ubiquitous pieces of furniture that exist, we spend an enormous amount of time around tables. There is a good chance you are sitting next to one of them right now. But how often do you actually take the time to reflect on how such a mundane object impacts your life – it almost feels ridiculous to even ask. Yet, many memorable experiences are facilitated around tables. Jokes, stories, and secrets are shared around the table. Family recipes are passed down from generation to generation at the dinner table. Creative projects are brought to life at the workshop table. Negotiations and interrogation are held on opposite sides of a table. You might have even fallen in love with someone in the presence of a table.

As everyday things become increasingly intertwined with the digital, their roles shift, blending the familiar with new dimensions for interaction and meaning-making. Digitisation is transforming our everyday life, changing the way we communicate (less face to face), informing the decisions we make (how you choose where to go for dinner), shaping new habits (scrolling our phones in the bathroom). Digitalisation is not just changing us but also the everyday things we are surrounded with – tables being no exception. If a table all of a sudden has a screen in it, does it still feel natural to place a mug of warm coffee on it? Adding computation to everyday things is a form of defamiliarisation in itself. Interactive tables are defamiliarised tables by definition. They essentially are tables made interactive through computational additions to their materiality. Here, computation can be seen as a design material beyond the traditional,

not merely a means to create functionality but as something with new inherent properties and potentials to be explored – such as responsiveness, dynamic behaviour, and expressivity [1]. Even though these tables all possess new capabilities and possibilities offered through their computational properties, their former form factor or physical design is still reminiscent of an ordinary table.

An ordinary table already determines perhaps more of our interactions than we might be aware of. Think about how the seating arrangement might influence your conversation with another person. Sitting on opposite sides of a table leads to a more transactional social dynamic, whereas sitting next to another at a round table imposes a sense of collaboration and equality [2]. Ordinary tables are thus entangled and defining – socially, practically, politically.

If we think of interactive table as an entangled piece of computational furniture, it is not merely a static piece of furniture but a dynamic participant in social and environmental interactions, adapting to and shaping the activities around it. Current examples of interactive table designs published in HCI [3], [4], as summarised in Paper I, showcase tables with actuating properties that might recognize different objects placed on them [5], promote certain eating behaviour [6], or adjust its shape or functionalities based on the individuals interacting with it [7]. In this way, the table becomes part of a socio-material network, where its technology mediates and redefines the interactions among people, objects, and spaces around it.

Due to the agency granted through computation, this entanglement goes beyond mere functionality, as the table – more actively than a non-interactive table – influences behaviours, routines, and social dynamics. By blurring boundaries between the object, its actuation, and people, the table’s interactions with people reflect a complex, relational ontology where both the thing and the people involved are co-constituted through these ongoing interactions.

In design research we have a long-standing history in not only designing to solve problems, but also to challenge and critically examine potential directions in which technology could take us. While previous trends in interactive tabletop research primarily focuses on instilling computational matter for the sake of problem solving, this thesis aims to reimagine what a table *could be* in a digital age, what people do around them, and what new meaning might emerge from interacting with such things.

In a broader sense, this thesis investigates how everyday things can be reimagined in a digital age by defamiliarisation. There is a certain power in leveraging the triviality and familiarity of things – such as a table – and disrupting its existing associations by redesigning it. Defamiliarisation invites us to critically reflect on the roles these mundane things currently play – how they unconsciously shape our behaviours, relationships, and environments. By contrasting the habitual and uncovering the unnoticed, defamiliarisation has

the power to not only to question our implicit assumptions and values, but also allows us to reimagine their purpose as their materiality becomes increasingly more computational. This technique is particularly suitable in design research, as it challenges us to investigate alternative approaches to traditional design approaches that favour computation primarily for pragmatic reasons such as optimisation and problem-solving. Instead, this thesis seeks to defamiliarise everyday things with a sense of curiosity and playfulness, inviting for reflection, critique, and speculation on how technology might transform the intricate relationships between people and the things that shape their daily lives in a digital age. Tables, for their ubiquity, triviality, and deeply entangled nature, serve as the ideal candidate for defamiliarisation and theoretical exploration.

Thus, the overarching aim of this PhD research is to **rethink everyday things in an era of digital transformation**.

In this thesis, I will tackle part of this aim by addressing the following two research questions:

RQ1: *How could everyday things be remade through defamiliarisation?*

RQ2: *What are the lessons learned from changing the materiality of tables through actuation?*

1.1 A Clarification of Terminology

For the sake of clarity, it is important to briefly define what I exactly mean by the keywords used in the research questions. More background on the theories that drives these definitions are explained in Section 1.2.

What is an everyday thing?

A “thing” is more than just a physical object. In this thesis I will look at “things” through an entangled perspective [8]. While it is easy to focus on the physical design aspects of an object, a “thing” comes with a package of relationships, interactions, and influences that shape and are shaped by its surroundings. Unlike traditional views that treat objects as static, passive entities, a “thing” in entanglement theories sees it as actively involved in a web of socio-material connections [8]. It has agency – implying it can affect and be affected by humans, technologies, environments, and social norms [9].

For example, a smartphone isn’t just a device but a “thing” that interacts with and shapes our social lives, daily routines, and even identities through its various affordances (like notifications or apps). In this sense, “things” are dynamic participants as part of a broader relational network, with their roles and meanings constantly shifting depending on how they are used, by whom, and within what context.

A thing becomes *everyday* as we start to live with them, spend time with them, when they become embedded in our everyday routines and are integral to the way we live. They become familiar things once we have grown so accustomed to them that we don't question them any longer.

Product archetypes, such as tables, chairs, benches, work particularly well in the context of defamiliarisation due to their qualities of being mundane, extremely ordinary, or uninteresting. Their entanglements beyond the object is often not considered – rendering them as passive, without agency. These qualities make for a suitable base to emphasise contrast by making strange through technology.

What is actuation?

By actuation I speak about setting something in motion, physically, through computational matter, as programmed by the designer. In the world of micro-controllers, actuation is often described as the opposite of sensing. Whereas sensing technologies convert physical phenomena into electronic signal (input), actuating technologies use electronic signals to activate a reaction (output). Thus, actuators, such as motors, vibrators, air fans, cause a physical change to the world, typically as a response to an input of a sensor.

A simple example of a table with actuation properties is the typical height-changing office desk, which uses linear motors to alter the height of the table based on a user's input. Paper III uses air fans hidden underneath the tabletop as a subtle form of actuation. Paper I presents an overview of interactive table with various actuation properties, and classifies four distinct action forms found in these tables.

What is the materiality of a thing?

Wiberg [10] writes about the *material turn* in HCI, where the lines between digital and analogue materials are increasingly blurred. Following this understanding, by the materiality of a thing I refer to a broad interpretation of the material markup of a thing, beyond the traditional physical material properties such as material, colour, finish, size, weight, shape, etc. As objects are becoming more and more digital, computation can also be seen as a design material. It is a part of the material composition, such as the programmed chain of reactions based on what the object senses, computes, and actuates.

Paper II presents another lens on materiality, exploring shadows as an immaterial material in interaction design [11]. Paper III uses airflow as an ephemeral material to provide feedback to participants' responses. Computation, shadows, and airflow have their own subtleties and material properties that can be analysed and used for design as any other traditional material.

1.2 Background

In the following section I will provide a short rundown of the most prominent theoretical and methodological concepts that shaped my work. These are important to understand the framing of the thesis and will be referred to throughout the remainder of the book.

Design Research

My research is positioned within a design research framing, which characterises itself for its practice-based approach in generating knowledge. Cross [12] introduced the notion of “designerly ways of knowing”, advocating that design encompasses distinctive methods, separate from those of science or art. In categorizing design research, Frayling [13] described three approaches: *research into design* (examining design itself as a field), *research through design* (using design practice as a method to investigate questions), and *research for design* (creating knowledge to serve design practice). These contributions have been highly influential in establishing design as an academic discipline. However, Redstrom [14] calls for a shift away from what he describes as the “academisation” of design, proposing that practice-driven research should establish its own methods for theory generation, grounded in and through the act of making.

In this thesis, I adopt a research-through-design methodology [15], [16], leveraging my background in industrial design, to create, prototype, and deploy interactive tables in real-world settings. Through reflective practice [17], I aim to articulate insights that emerge from the design process and the engagements between people and the artifacts, to feed-back new knowledge to the current body of design research.

Through this practice, it becomes clear that the designing of tables includes more than simply giving shape to a materialistic table. It is much broader than that, as tables are always situated in social configurations and influence people’s behaviour, particularly as technology is embedded – as exemplified in the introduction. It is therefore worthwhile to consider tables as an entangled piece of furniture.

Entanglement HCI and Interactive Materiality

Frauenberger [8] describes we are currently going through the “Fourth Wave” of Human-Computer Interaction (HCI), which he calls Entanglement HCI. This represents a paradigm shift in how we view our relationship with technology. He suggests that as humans and technologies are increasingly intertwined, traditional boundaries between the two become unclear, raising new challenges in HCI research, ethics, and practice.

The previous three waves in HCI evolved from optimizing human-machine interactions (first wave), to enhancing user productivity within established contexts like the workplace (second wave), to acknowledging the messy, social, and emotional dimensions of everyday life in user experience (third wave).

The fourth wave, Entanglement HCI, draws from theories like Actor-Network Theory [9], Post-Phenomenology [18], and Agential Realism [19], emphasizing the “entanglement” between humans and technology. This means technologies are not just passive tools but actively shape human behaviour, identities, and experiences, leading to “ontological inseparability”, where people and technology are fundamentally connected. This entanglement concept challenges us to rethink knowledge, ethics, and responsibility since technology influences human actions and vice versa.

Wiberg [1] introduced the concept of interactive materiality, referring to the way physical and digital materials interact and are configured to enable and enhance user interactions. Since traditional objects are becoming increasingly computational, we can start to expand our understanding of materiality beyond the traditional design perspective, i.e. material choice, colour, texture, and form. An interactive object can possess material properties such as responsiveness, state-change, or agency [1]. This new understanding of what a material is with the current possibilities of technology, challenges designers to consider not only the physical attributes of materials but also their dynamic and temporal qualities, opening up new forms of engagement and meaning-making through interaction.

In my research, entanglement theory provides a lens to critically examine the evolving role of tables as their materiality becomes increasingly computational. By embedding actuation and computation into these everyday things, tables transition from static pieces of furniture to dynamic participants in socio-material networks. This shift opens up new design opportunities and challenges. This thesis aims to tackle a part of them – exploring how a change in materiality reshapes behaviours, relationships, and social dynamics in meaningful – or meaningless – ways.

Concept-driven Design and Programs

In contrast with situation-driven design approach, which follows a typical user-centred design process where there is a client and a problem to be solved, concept-driven design is a more exploratory design approach. Concept-driven design does not try to solve a problem per se, but rather designs to advance a theory by “manifesting theoretical concepts into a concrete design” [20]. Stolterman and Wiberg point out that the artifact is *the carrier of knowledge*, where design concepts can act as a proof-of-concept or an embodied exemplar of a theory.



Figure 1.1: Azalea: idle (left), initialised by “swallowing” the phone (center), in use by animating the pillow with the phones actuators (right).

Redstrom [21] proposes a programmatic take on developing design theory. Theories can fall under a program, with each its own set of values, methods, principles, following a specific *worldview* [21]. For example, slow technology emphasises temporality in design, and aims to design for slowness and reflection [22], [23]. Ludic design is designing for playfulness and curiosity [24], soma design is about designing with the body [25]. These programs all have their own *worldview*, with their own theories, methods, and exemplary design artifacts. Concept-driven design is a methodology that fits particularly well in combination with designing under a program to advance the knowledge within the umbrella of that worldview.

The majority of my work adopts a concept-driven, programmatic approach to research-through-design. For example, Azalea – a project preceding my PhD – follows a concept-driven design approach in redesigning mobile phone usage for long distance communication [26]. Informed by soma design [25], this project sought for a more embodied way of communicating through phone calls – introducing the strong concept of *diminished reality* which proactively prioritises the removal of distractions over increasing resolution in distant phone communication. Figure 1.1 shows the initialisation sequence of Azalea. Paper II is another programmatic contribution to soma design, by demonstrating how designer can cultivate a sensibility and somaesthetic appreciation for shadows. Paper III builds on the program of Designing for Homo Explorens [27], aspiring values of playfulness, curiosity, and exploration through interactive installations.

Intermediate-Level Knowledge and Strong Concepts

Intermediate-level knowledge is form of knowledge that resides on a level of abstraction between a universal theory and a particular case [28]. It is more general than an *ultimate particular* [29], a specific, concrete design instance that embodies a unique combination of design decisions, interactions, and material qualities, that are highly dependent on a particular context. It is also more specific than a universal theory, so it does not try to make general claims. Figure 1.2 shows a graphical mapping of a variety of intermediate-level knowledge forms, vertically distributed on an axiom from particularity (bottom)

to universality (top).

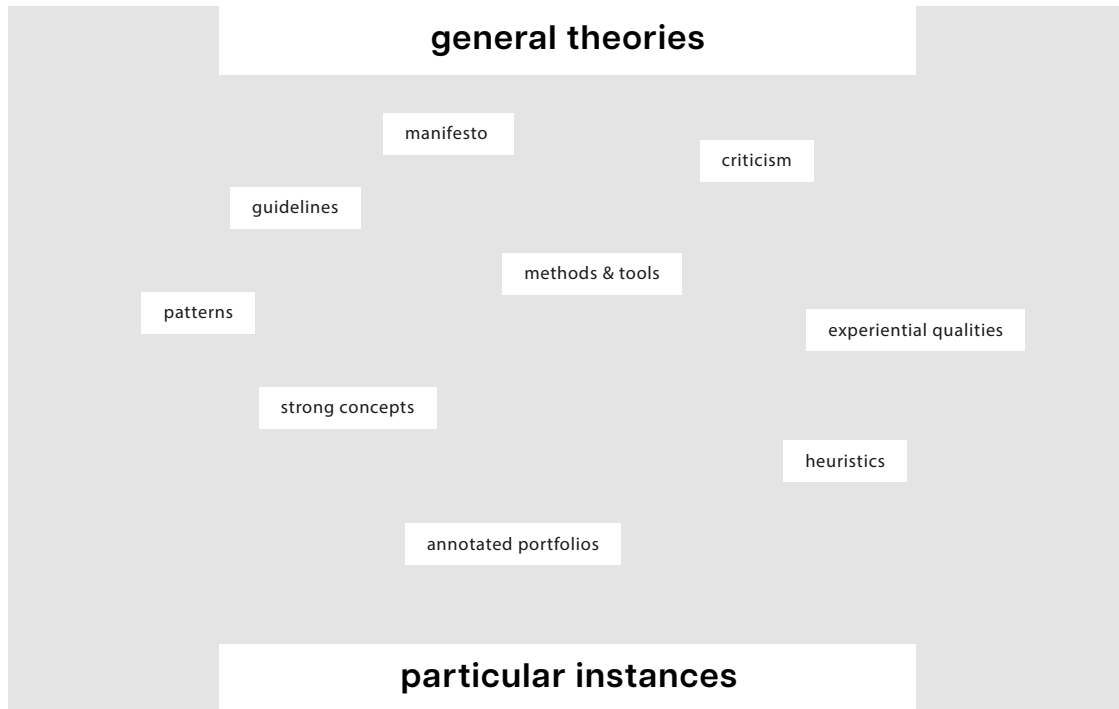


Figure 1.2: An overview of the various forms of intermediate-level knowledge. Adapted from [28].

Strong concepts is one type of intermediate-level knowledge that plays a central role in this thesis. Paper III, builds on strong concepts as a constant factor for design remakes which will be introduced at the end of this section. It's called a *strong* concept for it's generativity for design. They carry a generative design concept applicable across a diversity of individual artifacts, use situations, and even domains. The Undertable, presented in Paper II and III, reapplies the strong concept of “encouraging a bare-skin connection between strangers” stemming from previous work on the Mediated Body [30].

Defamiliarisation

Perhaps the most crucial piece of theory underpinning this thesis is the technique of defamiliarisation. Defamiliarising something presupposes an existing state of stability, familiarity, and unexamined assumptions. By deliberately disrupting this state—through modifications, dramatisations, additions, or shifts in perspective, it challenges taken-for-granted associations, prompts critical reflection and, at times, sparks a renewed appreciation.

Within interaction design, defamiliarising a familiar object opens new design spaces for exploration, inviting us to speculate on how the current could be reimaged. This, in turn, encourages the speculation of alternative futures and a critical view of present assumptions by juxtaposing the familiar with

unfamiliar perspectives. The power behind the concept of defamiliarisation lies in its simplicity. While not always explicitly named as such, defamiliarisation is a common technique found in many HCI projects. It is also fairly common in design education to include a defamiliarisation exercise to stimulate creativity.

The roots of defamiliarisation lie in literary theory, introduced by Viktor Shklovsky as *ostranenie* – a technique for “making strange” that he described as essential to art [31]. In his words:

*”In order to transform an object into a fact of art, it is necessary to **detach** it from the domain of life, to **wrest** it out from the web of familiar associations, to **turn** over the object as one would turn over a log in the fire”. – Shklovsky [32]*

Shklovsky’s process – *detach*, *wrest*, *turn* – has been adapted across disciplines, including HCI. For instance, Wilde, Vallgård and Tomico [33] developed a framework for embodied ideation that follows a similar process to make strange – *disrupt*, *destabilise*, *emerge*, *embody*. Through this sequence of steps, estrangement can challenge existing patterns and values, enabling new ideas and behaviours to emerge, which are then embodied in design.

Furthermore, Bell, Blythe and Sengers [34] use defamiliarisation as a writing style to critique contemporary design practices of everyday objects within domestic settings. Their work challenges the underlying assumptions about technology in the home, problematising prevalent design goals in HCI at the time (2005) – such as prioritizing efficiency or relying on stereotypical understandings of users. Through ethnographies of domestic technologies in households across the US, UK, and Asia, they present three narratives that make the familiar strange. As they explain:

“Ethnographies of domestic technologies cannot help but make them strange. The act of, for example, analyzing a kitchen sink terms of its cultural or social significance would seem to many people like quite an odd thing to do. But it is by questioning the assumptions inherent in the design of everyday objects that HCI has always opened up design spaces, pointing towards better and more innovative designs.”
– Bell, Blythe and Sengers [34]

Counterfactual Artifacts

More closely related to the defamiliarisation of everyday things, Wakkary, Odom, Hauser *et al.* [35] write about *material speculation*, where researchers critically examine potential speculative worlds by creating and situating tangible artifacts in actual contexts. Instrumental to this approach is the use of *counterfactual artifacts*, which are artifacts designed to leverage the familiarity of everyday objects to then contradict them through redesign, thereby challenging existing worldviews. These artifacts function through an “if...then...” logic, disrupting current understandings to provoke the imagination of alternative possibilities. By embodying a speculative proposition, such artifacts

bring these imagined worlds into the actual, allowing them to be experienced, critiqued, and empirically examined.

Two examples of counterfactual table artifacts – that are also included in the literature review (Paper I) – are the table-non-table [36] and deformTable [37]. To exemplify, the table-non-table is somewhat reminiscent of a coffee table – but purposefully designed at an inconvenient height for humans. A few times a day it subtly moves its position in a small radius. It is made of an aluminium chassis equipped with a stack of 1000 white sheets of paper. These odd features are purposefully designed to challenge typical utilitarian uses of tables and allow for inquiring into how humans and non-humans appropriate such alien yet familiar artifacts. The Undertable (Paper III) takes inspiration from these counterfactual tables in defamiliarising tables by making playful through actuating technology.

In the discussion chapter, I will further expand on how everyday things can be defamiliarised through design remakes (Paper III) and by establishing unhabitual habits around everyday things (Paper II).

Design Remakes

Design remakes is not widely recognised as a formal method to conduct research (yet). While this is partially a contribution of this thesis, stemming from the work in Paper III, I will briefly introduce this method here already to foreground the discussion in Chapter 3.

The idea of using design remakes as a research methodology came from Bergmark and Fernaeus’s *interaction design remake* study. Here, they propose design remakes as a response to the replication crisis [39], offering an adaptation better suited to a practice-based epistemology [38]. Compared to a replication study, the interaction design remake focuses more on reinterpretation and remaking of an existing design. Their ambition is to use the original study as a starting point, aiming to preserve most of the “core narrative” and “interactive gestalt” of the original work, while allowing themselves to modify features of the design [38]. Finally, the remake is designed with the intention to gain insight into the changes in socio-technological contexts over a decade.

Paper III further develops *design remakes* as a methodology by presenting a case study of remaking the Mediated Body [30]. This study retains the same strong concept from the original study while redesigning the prototype and deployment context. It calls for design research to directly engage with previous design case studies in line with a practice-based approach. It further explores design remakes as a method for generating intermediate-level knowledge, arguing that design research can develop its unique approach to engaging with prior work, embracing its creative and context-sensitive nature rather than adhering to replication standards suited to other sciences.

1.3 Introducing the Included Papers

This compilation thesis includes four publications, each addressing parts of the research questions and collectively contributing to the understanding of how we can rethink everyday things through defamiliarisation and actuation in the materiality of tables.

Paper I: Literature Review on Actuated Tables

The first paper [4] establishes the foundation for this thesis by reviewing actuated tables – a type of interactive table with actuating properties, such as changing-shape, mobility, height adjustments, or subtler transformations. It reviews fifteen actuated tables design based on the concept and purpose behind the table, the form of actuation, and the research approach used to study them. This paper highlights how actuation grants tables a form of agency in social situations, and also offers a high degree of adaptability and flexibility in spatial arrangements. The paper addresses **RQ2** by showcasing how actuation alters the materiality of tables, offering a portfolio of examples of a variety of actuated table manifestations.

Paper II: The Shadows Paper

The second paper [11] opens up another lens of the materiality found in actuated tables. It places shadows – an immaterial material – in focus as an underexplored component of the materiality in interactive artifacts, and highlights how designers can develop a sensibility and somaesthetic appreciation for shadows. Through an analysis of the book “In Praise of Shadows” by Jun’ichirō Tanizaki, we developed a set of literal and metaphorical shadow-related themes. These are exemplified through an artifact analysis of everyday tables found on a *dérive* through the city. In search for the shadow-side of tables, we developed the curious habit of looking underneath the table to find out if this was designed for. The discovery of the underside of tables as an unused design space became a part of the inspiration for the Undertable (Paper III). This paper relates to **RQ2**, as it probes the interplay between material and immaterial aspects of tables. It also touches upon **RQ1** by describing how everyday can be defamiliarised by relating differently to them through the establishment of new habits – such as looking underneath a table.

Paper III: The Undertable

The third paper [40] presents the Undertable, a research-through-design project leveraging the familiarity and ubiquity of tables to create a playful experience through defamiliarisation. As a design remake of the Mediated Body [30], the Undertable re-instantiates the strong concept of *encouraging bare-skin touch between strangers* in the form of an actuated table. The Undertable actuates an array of air fans hidden underneath the tabletop as a subtle response to detecting bare-skin contact between two people – granting an alibi for the playful exploration of conductivity and touch. This study further expands the discussion of this thesis: how everyday things can be remade through defamiliarisation. In this case, actuating materiality hidden in an ordinary

table-like artifact is instrumental for facilitating a playful experience, providing a space and stimulants to challenge norms of touching someone bare-skin and sparks reflection around the meaning of touch. This paper addresses the core of this thesis by tackling both **RQ1**, by demonstrating how remaking an artifact defamiliarises its use and meaning, and **RQ2**, by as a use case on how actuation can transform an object's materiality.

Paper IV: The Sixth Finger

The final paper, The Sixth Finger [41], deviates from the main focus on tables and everyday things. Instead, it is an initial step into the direction of exploring how actuation and defamiliarisation can lend itself for accessibility purposes – a direction I aim to pursue after my licentiate. This study focuses on improving the design of the Sixth Finger through actuation, an assistive robotic finger that helps post-stroke people regain independence in daily life by rehabilitating abilities lost after the stroke. The study reports on a focus group study, proposing design recommendations for future designing supernumerary robotic fingers.

Together, these four papers aim to address the research questions of this thesis and support future directions after my licentiate. Next follows a more elaborate overview per paper, including a motivation, process overview, contributions, and a discussion in line with the overarching narrative of this thesis.

Chapter 2

Summary of Included Papers

This chapter provides a summary of the papers included in the thesis. For each paper, I start with brief description of the rational behind the work, then I outline the process of how the study was conducted, followed by an overview of its contributions, and conclude with a discussion in the light of the narrative of this thesis.

2.1 Tables Got Moves: A Review on Actuated Table Designs

This first paper is meant to provide an overview of actuated table designs in HCI. Prior research in the domain of interactive tabletops focused on tables with a large multi-touch screen embedded into the tabletop, or on interactions with ‘tangibles’, physical objects that interact with a tabletop detected through a camera-tracking system in synch with a projector (see Figure 2.1). My aim for this literature review was to delineate and establish *actuated tables* as a niche area of research, and as an emergent type of interactive table.

The paper provides an overview of the state-of-the-art in actuated tables, based on the past decade of publications in HCI. Through mainly a systematic review process, fifteen papers were included. Each present a unique actuated table design, investigated based on the concept behind the design, the table’s actuation properties, and the research methodology applied to study the prototype.

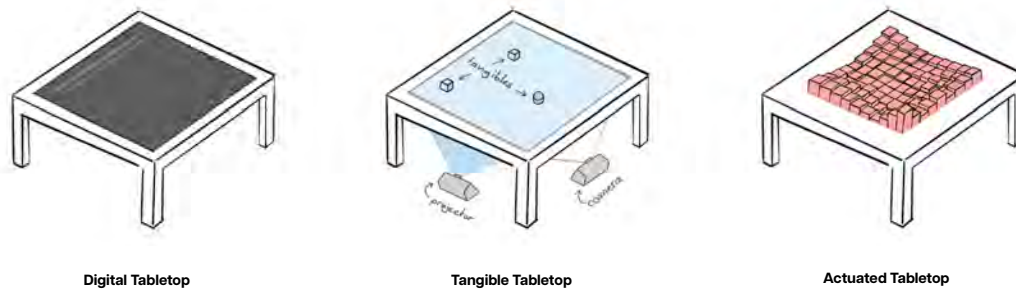


Figure 2.1: Three recurring styles of interactive tabletops: digital, tangible, and actuated tabletops.

Process

Scope: The ACM Digital Library was used to gather a representative set of papers presenting an actuated table design, focusing on Human-Computer Interaction (HCI) aspects rather than technical implementations found in other repositories like IEEE.

Keywords: Given the lack of a clear definition for “actuated table”, two authors (from now on we) conducted a broad search using keywords such as “table,” “tabletop,” “design*,” and “interact*.” This initial search yielded 198 research papers from January 2012 to December 2022.

Exclusion criteria: We agreed on the following exclusion criteria:

- The publication should present an actuated table design with a concept and a prototype.
- The publication should be of a full paper, demo, or extended abstract. Surveys and review papers were excluded but reference crawled.
- In case of overlapping paper reporting on the same design, the most substantial paper was included.
- Papers focusing solely on technical details instead of interaction design aspects were excluded.

Screening: The 198 papers were screened against the exclusion criteria by reviewing titles and abstracts, and when necessary, the full content of the articles. In case we were uncertain whether a design would classify as an actuated table, we discussed it together – thereby shaping a clearer focus of the review. For instance, a table with actuated swarm robots operating on a tabletop would be excluded as actuation takes place in an entity separate from the table. We were ultimately left with fifteen papers.

Coding: A coding scheme was developed to categorize the selected papers based on concept-centered, table-centered, and research-centered attributes (see the full paper for the descriptions of each attribute in Table 1, and Table 2 for

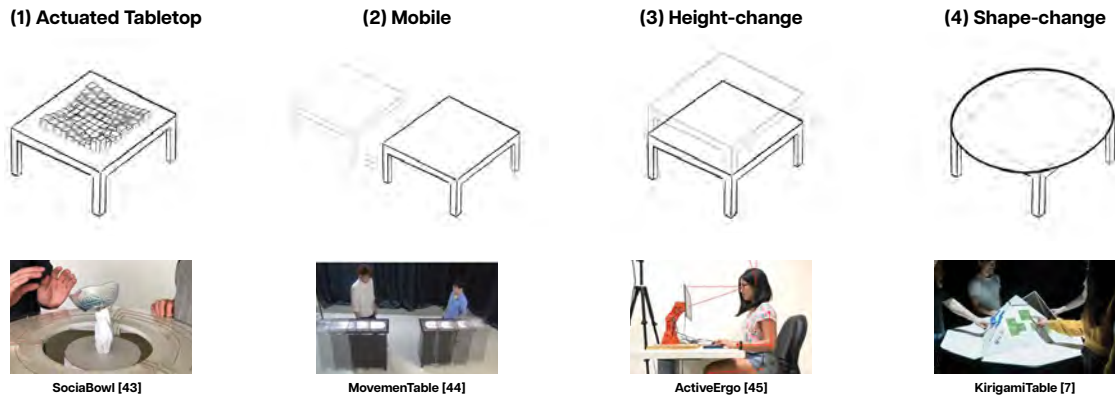


Figure 2.2: Three recurring styles of interactive tabletops: digital, tangible, and actuated tabletops.

an overview of the coding criteria). We first independently coded each article individually following the coding scheme, and then discussed their findings to ensure consistency and accuracy.

Contribution

First and foremost, this paper defines actuated tables as a type of interactive table that can physically move by changing its shape, orientation, or position. To the best of my knowledge, this is the first paper to shed light on actuated tables, sketching an overview of the current state of actuated tables in the past decade of HCI research based on concept-centered, table-centered, and research-centered attributes.

We also identified four preliminary forms of actuation: *actuated tabletop*, *mobile*, *height-change*, and *shape-change* (Figure 2.2). They highlight the diversity in actuation styles and can be expanded in future research. Finally, we lay out a set of future directions to consider when designing and researching actuated tables.

Discussion

This paper aimed to form a foundation for the remainder of my PhD. By reviewing the main body of HCI literature, this paper would help to situate my work within HCI and identify research gaps to focus on. The goal since the start of the PhD was to adopt a prototyping-heavy research methodology where I could apply my skillset as an industrial designer. This made it attractive to focus on the materiality of interactive tables beyond digital screens – which a significant proportion of interactive tabletops are focusing on.

Even though there is a large body of interactive tables in the history of HCI¹, most design revolves around the tabletop. This article broadens the design

¹ACM's Interactive Tabletops and Surfaces (ITS) was a conference dedicated to interactive tabletops between 2009 and 2015.

space around tables to not only focus on interactions centered towards the tabletop only, but examine interactions with tables in its entirety – a single entity beyond the tabletop, including the context they are situated in. These are aspects that become more relevant and interesting due to the dynamics that emerge with the table’s actuating properties, such as being able to move within a space, whereas most interactive tabletops maintain a physically static posture.

It further highlights the characteristics of what actuation in tables enables as seen in the fifteen included design. These were *social mediation* between people through the table’s agency enabled by its actuation, such as delegating turn-taking during meetings or nudging people to eat at a similar place during dinners. On a more practical note, we also saw a pattern of tables that provide *adaptability* by using actuation to transform the table from a horizontal surface to a wall-stand, and *flexibility* by rearranging the table when switching between group and individual tasks at work.

2.2 In Praise of Shadows: Sensibility and Somaesthetic Appreciation for Shadows in Interaction Design

This paper explores shadows as both an immaterial material and a metaphor for the hidden or subtle aspects of interaction design. When seen through the lens of materiality, shadows are often not considered as a material component to design with. In a metaphorical sense, this article highlights how “good” designs not only put care into the exterior aesthetics, visible to the eye, but also carefully crafts the internals of artifacts such as the electronics and enclosures hidden away from view. Informed by soma design theory, this paper argues how an aesthetic appreciation for shadows can be cultivated and passed on from person to person. Focusing on tables as an example, the goal was to examine how shadows are present in these everyday objects and exemplify through hypothetical interactive table concepts how designers can treat shadows as a design material.

Process

The research process behind this paper departed from Jun’ichirō Tanizaki’s inspiring writing on the aesthetic appreciation of shadows in his essay “In Praise of Shadows” [42]. We analysed the book using thematic analysis to form seven themes, displayed in Figure 2.3: placemaking, sensual, uncompromising, patina, mystery, haze, and pause.

We then embarked on a *dérive*, aimlessly wandering through the city while photographing non-interactive tables in public spaces, museums, libraries, and parks. Through an artifact analysis, we analysed and reflected how the shadow-related themes are present in relation to the tables we noticed during the *dérive*. For example,

Based on the analysis, we developed three concepts of interactive tables to illustrate how the shadow-related themes can be manifested in interaction design. One of these concepts served as the inspiration for Paper III, which we continued to prototype and evaluate through several deployments.

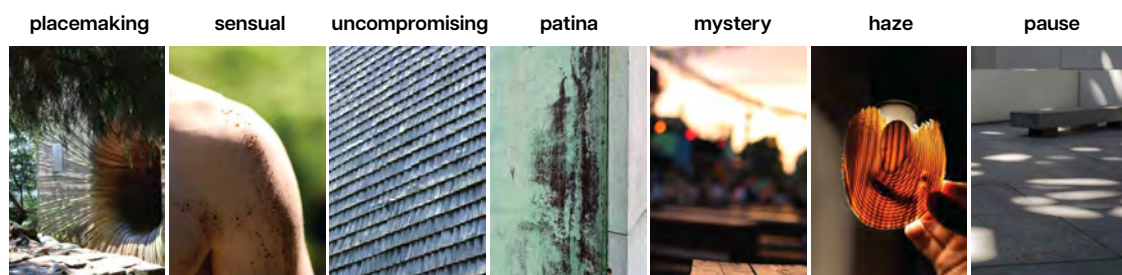


Figure 2.3: A visual overview of the seven themes we derived from “*In Praise of Shadows*” by Jun’ichirō Tanizaki

Contribution

The first contribution is the recognition of shadows as a material for design. This paper frames shadows as an intricate and context-sensitive design material, that can be used intentionally as a part of an interactive artifact's materiality.

We further introduced three design concepts and a prototype that make this rather abstract design material more tangible.

Lastly, this paper illustrates how a sensibility for shadows can be developed and frame *sensibilities* as a form of intermediate-level knowledge that can be cultivated and embedded in design practice.

Discussion

Appreciating shadows as a design material can introduce atmospheric and subtle qualities to interactive artifacts, offering an antidote to the rigid, utility-focused aesthetics that dominate most computational designs. In this paper, we reflect on how this sensibility changed our perception on design, advocating for HCI and interaction designers to embrace ephemeral and metaphorical elements, such as shadows, in their work.

In relation to the story behind this thesis, this project sparked the idea of defamiliarising tables through habits. In search for the shadows of tables during the *dérive*, we developed the practice of looking underneath tables out of a curiosity whether the underside was as carefully crafted as the rest of the tables despite being hidden from view. This also changed the way we somatically related to tables as it was not uncommon to lay underneath a table – something an adult would otherwise rarely do. This new way of relating to tables, as well as the discovery of the underside of a table as an underexplored design space proved to be generative for design, ultimately forming the inspiration for paper III.



Figure 2.4: One example of a table found during the *dérive*. The multiple textures on the tabletops create a play of shadows and light. The sun shines through small holes, exaggerating the surface's patina of the corrugated metal.

2.3 The Undertable: A Design Remake of the Mediated Body

This project was inspired partially by the underexplored design space under the table as pointed out in Paper II, and partially out of a fascination for a design I have been a fan of since the early days of my interaction design education: the Mediated Body by Hoby and Löwgren [30]. Energised by the video documentation of the field study, I was captivated by the brilliance of using technology as an alibi for playful interaction between strangers and challenging social taboos. The concept was so compelling that I felt the need to prototype a similar interaction, allowing it to be experienced first-hand. This prototype ultimately developed in the Undertable, as a design remake of the Mediated Body – a tribute to the original work by Hoby and Löwgren.

This paper contains the most substance in contribution to the topic of this thesis, building on the previous two papers. The design concept behind the Undertable is inspired by Paper II by looking at the shadow-side of tables – both literally and metaphorically. Influenced by the literature review (Paper I), it is also a case study on how a table’s agency granted through actuating properties, becomes an active social mediator between people.

Ultimately, this paper’s aim is to study how changing the materiality of mundane objects, such as tables, with actuating technology can have a defamiliarising effect. Framed as a counterfactual artifact (Section 1.2), the Undertable is designed to disrupt and challenge the conventional utility of tables while remaining the conventional design of an ordinary table. Through deployments of various iterations of prototypes of the Undertable, we were curious to study what meaning people derive from such a defamiliarised object.

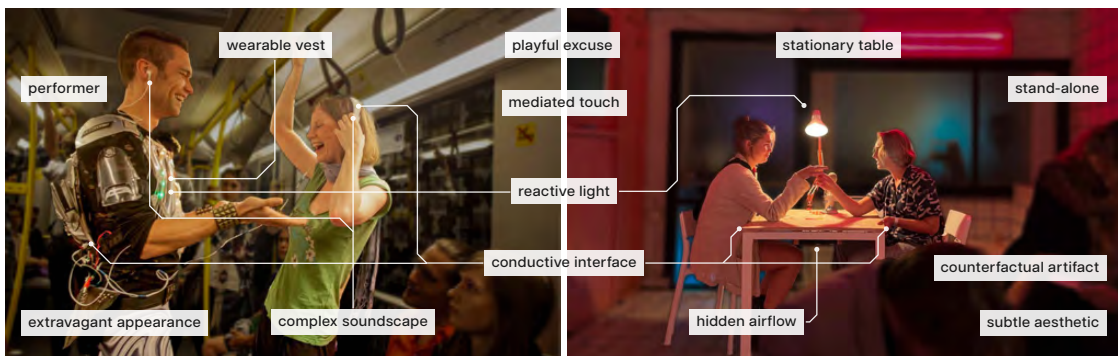


Figure 2.5: Annotated overview of shared and distinct qualities between the Mediated Body (original, left) and the Undertable (our remake, right). Image credits: ©Mads Hoby

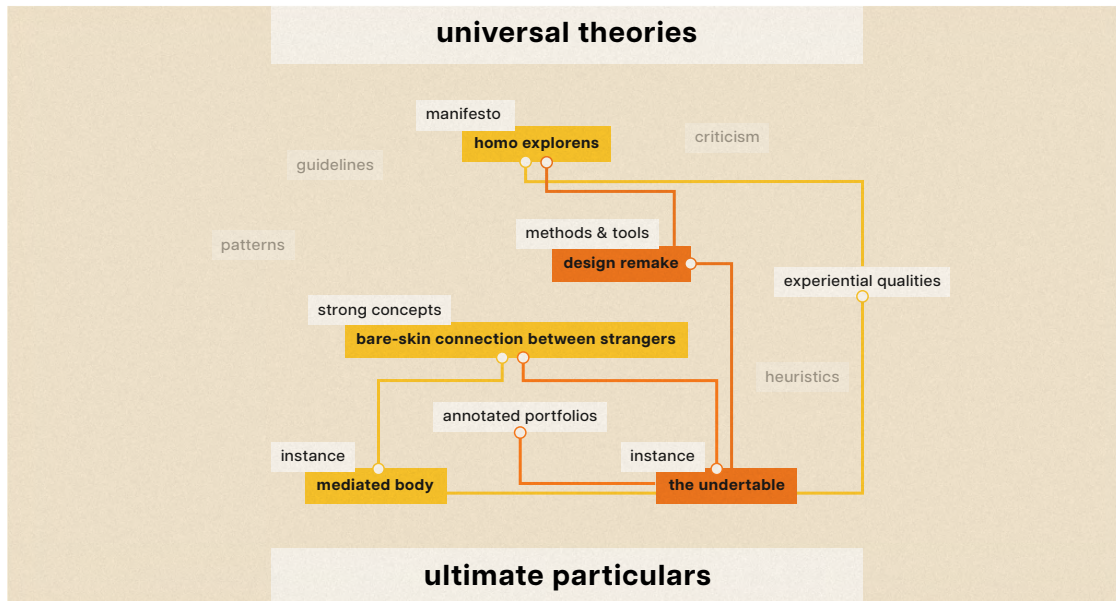


Figure 2.6: An overview of the knowledge-making structure of our project. Adapted from Höök and Löwgren’s mapping of intermediate-level knowledge [28].

Process

Figure 2.6 shows a graphical overview of the knowledge production behind this study. Using design remakes as a methodology, we started with by developing a prototype inspired by *The Mediated Body*: an interactive vest worn by a performer inviting strangers into a playful experience through bare-skin connection between strangers. *The Undertable* was designed as a counterfactual artifact to reimagine a table, turning it into an interactive artifact with hidden conductive brass strips and computer fans that activate when participants touch each other bare-skin.

We report on our own first-person experiences of the design process, which consisted of an iterative sequence of prototypes: the *Flimsy Table* (low-fidelity, proof-of-concept), the *Nomadic Table* (a portable kit for events), and the *Subtle Table* (self-explanatory and stand-alone). These prototypes were deployed on tested in various contexts, including a design studio, academic events, a karaoke party, a cultural party venue, and a university library.

We gathered observational data through audio and video recordings of the play sessions with the *Subtle Table* and conducted interviews with participants in pairs after. These were analysed through a reflexive thematic analysis to form five themes that capture a general flow of the participants’ experiences, which we called “an odd invitation”. Our analysis of the *Undertable* contributes a new theoretical aspect to Hoby’s initial manifesto on *Designing for Homo Explorens* [27].

Contribution

Firstly, this paper contributes with a series of counterfactual prototypes inspired by the Mediated Body that challenge the familiarity of tables by mediating playful interactions between strangers.

Second, it reports on a sequence of participant studies summarised into the notion of “an odd invitation”. We expand on the former theory of *Designing for Homo Explorens* [27] by adding an additional aspect – the odd invitation.

Lastly, this project develops design remakes as methodology for design research (which I will discuss in more detail in Chapter 3). We end the paper with a call to the design research community to consider design remakes as a method to engage more directly with previous work. We articulate design remakes as a form of citation through design practice.

Discussion

The Undertable exemplifies our approach to defamiliarising everyday things by transforming a mundane table into a mediator of playful and intimate interaction between people. Through our design, we aimed to disrupt the habitual associations people have with tables as static, utilitarian objects by embedding hidden interactive elements underneath the tabletop. This defamiliarisation encouraged participants to reflect on their relationships with the table as well as with another, exploring their boundaries of intimacy, social norms, and their meaning of touch.

We also notices the inevitability of “tableness”: the inherent familiarity of a table. Participants often drew back to conventional uses, such as leaning, eating, or studying, completely ignoring the table’s interactivity. This tension between the familiar and the defamiliarised proved both a challenge and an opportunity.

Through subtlety and simplicity in the design, we created a space for participants to co-create meaning through their interactions, shifting the focus from the technology to the relational and sensory experiences of touch. This internal complexity between pairs reinforces the potential of defamiliarisation through designs as a means to facilitate reflection on current associations and spark new ways of relating to everyday things.

Finally, the Undertable demonstrates the value of design remakes as a generative method for design, as well as a methodology to add to or deepen the current body of knowledge in the design research community.

2.4 Enhancing Functional and Extra Motor Abilities: A Focus Group Study on the Re-Design of an Extra-Robotic Finger

This article is a result of a research collaboration with Khalifa University. The goal of this project was to improve the design of the Sixth Finger prototype, an assistive supernumerary robotic finger (SRF), developed to support motor function recovery and extend capabilities (such as grabbing objects) for post-stroke adults (Figure 2.7). The main aim is to create a more user-friendly, socially acceptable, and adaptable device that will allow people who have had a stroke to live more independently, following the basic Activities of Daily Living (ADL): ambulating, feeding, dressing, personal hygiene, continence, and toileting. This work serves as a first step to learn more about designing actuated robotics to address accessibility purposes, which could possibly be transferred to the design of actuated tables.

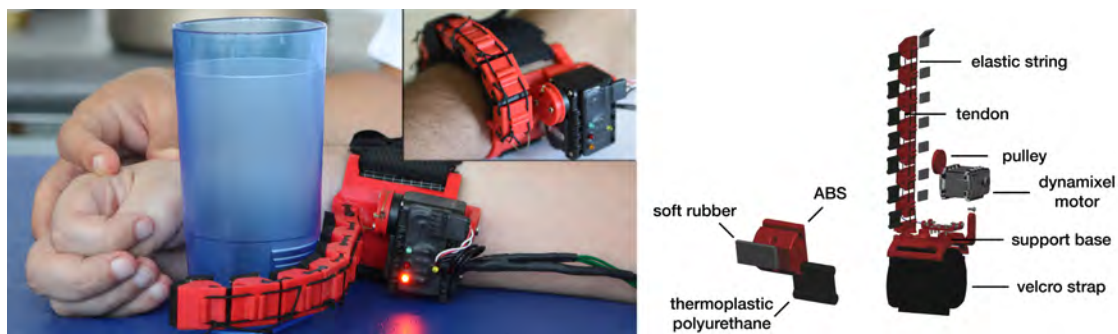


Figure 2.7: The Sixth Finger prototype worn by a user (left) and an annotated render of the prototype's components (right).

Process

This study is the first in an anticipated series of studies with various stakeholders towards a co-design approach to design an improved version of the Sixth Finger with the stakeholders (see Figure 2.8). We conducted a focus group study with engineers of different technical and biomedical backgrounds at Khalifa University. Future focus groups and co-design studies will include post-stroke adults, their relatives, doctors, clinicians, and designers. We conducted three rounds of focus groups with five engineers each. Per focus group, the participants first analysed and critiqued the current design based on ergonomic and social aspects according to their expertise area, and then ideated to suggest new design ideas under the umbrella of interaction, look-and-feel, functionality, and social impact. We then analysed the discussions using thematic analyses and summarised the key take-aways in the form of design recommendations.

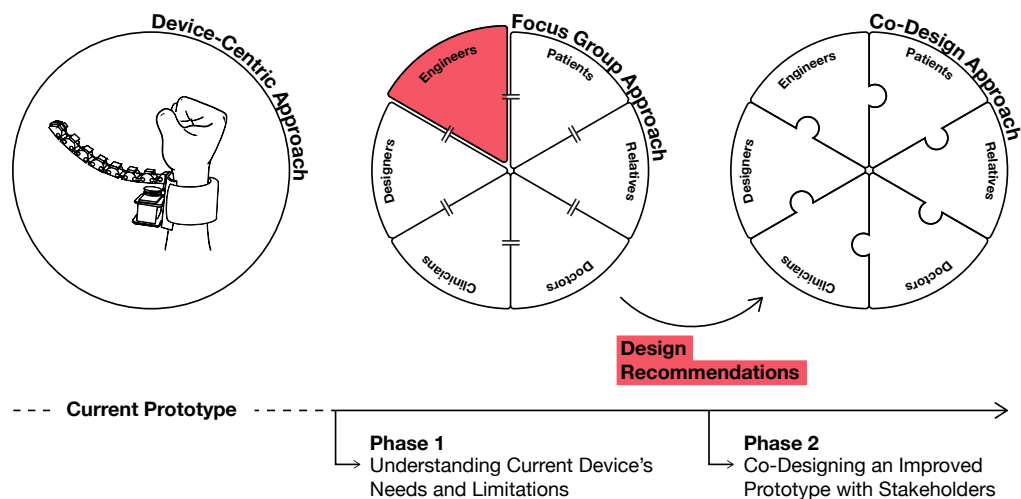


Figure 2.8: A representation of our approach towards a co-design process. The highlighted parts show the parts presented in this paper.

Contribution

The study results in seven key design recommendations for future SRF prototypes, based on an engineering perspective. These include designing for social and personal acceptance, enhancing aesthetics for customizable appearance, improving adaptability for different user needs, enabling multi-modal interaction (e.g., voice commands), and ensuring the device supports essential daily activities. These insights serve as foundational guidelines for a co-design process with the other stakeholders in the next phases of development.

Discussion and Future Steps

While this study falls slightly outside of the scope of this thesis, it serves as an initial step towards opening the design space for designing with accessibility in focus. This is one of the main directions for future work to study how actuation in tables can defamiliarise accessibility (see Section 3.4).

This paper calls for a more user-centred, co-design approach when designing supernumerary robotic limbs, which is currently an engineering oriented field of research. The paper highlights the need for a more inclusive development approach. Participants suggested the necessity of addressing not only physical but also psychological needs. Future design should then not only consider what the device can enable in terms of functionality, but also the social implications affecting the wearer.

Chapter 3

Discussion and Future Directions

Having outlined the research story, introduced the foundational theoretical frameworks, and provided an overview of the publications from my PhD, it is now time to tie everything together in addressing the research questions. The following sections draw upon the knowledge and experiences gained throughout my research activities to tackle these questions. Additionally, I will broaden the discussion by sharing insights that emerged from the process, extending beyond the immediate scope of the included papers. Finally, I will speculate on future directions for defamiliarising everyday things, proposing designerly approaches to further this research agenda.

To recap, the overarching aim of this thesis is to **rethink everyday things in an era of digital transformation**. I do this by exploring how their materiality and associated practices can be reimaged through defamiliarisation and actuation, with tables serving as a focal point for investigation. Below, I reflect on the insights from the included papers and how they address the research questions.

3.1 RQ1: How could everyday things be remade through defamiliarisation?

In its essence, defamiliarising is about contrasting the everyday – by disrupting the habitual. While there are probably endless possibilities of remaking everyday things through defamiliarisation, I will describe two primary strategies that emerges over the course of my research thus far: defamiliarising the everyday by changing their materiality through technology based on insights from Paper I and III, and defamiliarisation through the forming of unusual habits around everyday things based on Paper II. Finally, I will reflect on balancing familiarity and strangeness based on the insights of the Undertable project in Paper III.

Defamiliarising the Familiar with Technology

As stated I already stated in the introduction, interactive tables are always defamiliarised tables by definition. That is because technology embedded as part of its materiality introduces new possibilities, while retaining the recognizable form of a table. While I would argue that all fifteen designs from the literature review in Paper I are examples of defamiliarised tables, the two counterfactual artifacts (see Section 1.2) do this most purposefully and convincingly by challenging what a table is, and how current associations can be destabilised. For example, the table-non-table disrupts utility by being inconveniently low to the floor and uses actuation by occasionally moving its position as a subtle but question-inducing phenomena. The deformTable uses actuating technology to alter its shape dynamically when objects are placed on its tabletop, inviting for re-interpretation and new meaning making of such odd pieces of furniture. These designs, and the general concept of counterfactual artifacts behind them, have been foundational for my work on the Undertable in Paper III.

The Undertable (Figure 3.1) is another example of a table that is deliberately designed to stay close to the stereotypical appearance of a table¹. It aims to destabilise typical interactions around tables by hiding any technological impression – the air fans are hidden under the table, and the conductive brass bars are seamlessly implemented in the edge of the tabletop. In line with what counterfactual artifacts aim to achieve, the table appears ordinary yet opens up a space for critical inquiry and the temporary blurring of social boundaries. As a participant stated:

“But maybe that’s like easier. Just like when you have a first date and you go bowling, because then you can talk about the bowling. Here you can touch each other: ‘OH... it’s for the table...’ ” (Quote from P1, Paper III)

As this quote illustrates, the table is given agency though its actuated responses to bare-skin touch, serving as a social mediator or as an ice-breaker for the playful exploration of touching another person – something often considered taboo or unusual. For some, this lead to reflections on touch means to them:

“The more you think about it. The more important touch feels to me. Because now you understand that you don’t do it usually. Even when you hug your friends or whatever, even your family, you don’t touch their their bare-skin. It’s clothes or it’s a jacket, or it’s something... Which is, it’s still touch, but it’s not the same. This is different. Like, you don’t feel a shock from the electricity or whatever, but in your mind, something goes between you and the other person. It can get quite personal.” (P12, Paper III)

¹The design is a modified version of IKEA’s MELLTORP, chosen for its generic look and susceptibility for redesign.



Figure 3.1: Still footage from the Undertable deployments at Kolgruvan (a-f) and the university library (g-l) in Paper III.

At the same time, its familiarity and functionality as an ordinary table remained intact, with many people entirely ignoring its interactive potential and using it for conventional table activities. For example, two friends found the table an ideal spot to take a break from the party and enjoy their kebab (Figure 3.1e). In the library, students occasionally chose the table for peaceful studying, while others used it simply as a surface to leave their belongings. In Paper III, this phenomenon is referred to as *inevitable tableness*.

Beyond tables, my previous work on Azalea (Section 1.2, [26]) exemplifies how defamiliarisation can be applied to other everyday things, such as smartphones. Rather than adding technology to an analogue object, Azalea changes a phone’s materiality by repurposing the hardware already in place. The project uses a smartphone’s sensors and actuators to animate a paired pillowcase, facilitating communication through ambient sound and light instead of the typical cognitive-visual interface of apps. This approach critiques the dominant cognitive interaction style of smartphones by defamiliarising the device – removing its association with the phone being a source of distraction and instead emphasises movement, physical presence, and embodied interaction.

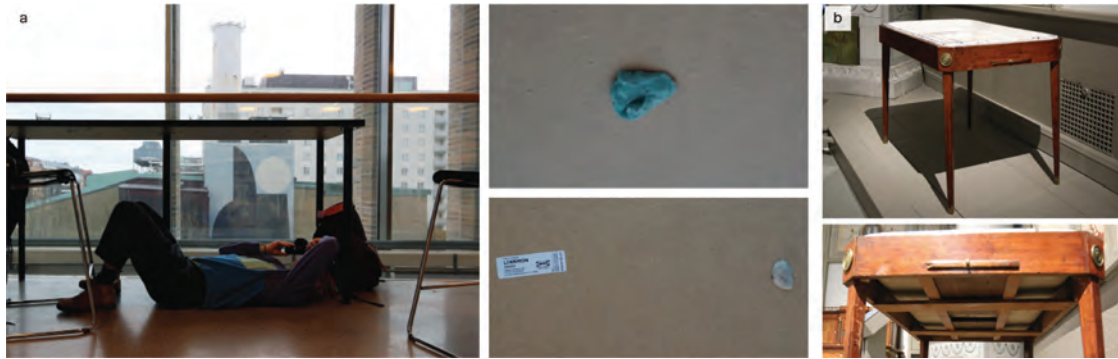


Figure 3.2: Examples of pictures taken from underneath tables during the work on Paper II. A: chewing gum under a library table, B: the neglected underside of a historical tea table.

Defamiliarisation through Strange Habits

In Paper II, the new habit of looking underneath tables, which emerged during a *dérive* while photographing tables in the city, quickly became a generative practice. More often than not, we found nothing particularly noteworthy beyond chewing gum stuck to the underside of the table (Figure 3.2a). This even extended to a visit to a design museum, where we discovered that the underside of tables has been historically neglected. For example, Figure 3.2b shows a delicate tea table from the 1750s, carefully crafted on all visible sides, while its underside is comprised of rough supporting wooden beams—an aesthetic mismatch with the rest of the table.

Although this exploration did not lead to striking discoveries as initially hoped for, it revealed the underside of tables as a neglected space with untapped potential. This observation became an opportunity for design, inspiring the concept for the *Undertable* (Paper III). It exemplifies how engaging with everyday objects differently – by seeking hidden or overlooked qualities – can lead to new perspectives and can be generative for design.

This practice not only defamiliarises the table itself but also changes how we somatically relate to things. For instance, I spent a lot of time crouching or lying underneath a table (Figure 3.2a) – a behaviour typically considered outside the norm. This aligns with Wilde, Vallgård and Tomico’s framework of estrangement through embodied ideation [33], showing how disrupting habitual behaviours can be a powerful tool for design. By disrupting the standard practice of sitting or standing at a table – keeping our faces above the tabletop’s height – new perspectives emerged, which could then be embodied in design (e.g., the *Undertable*).

The methodology used in Paper II is but one example of a defamiliarising practice in the study of everyday things and could also be adapted to explore concepts beyond shadows, such as entanglements or other materiality aspects. What might happen if we had chosen a different book instead of *In Praise of*

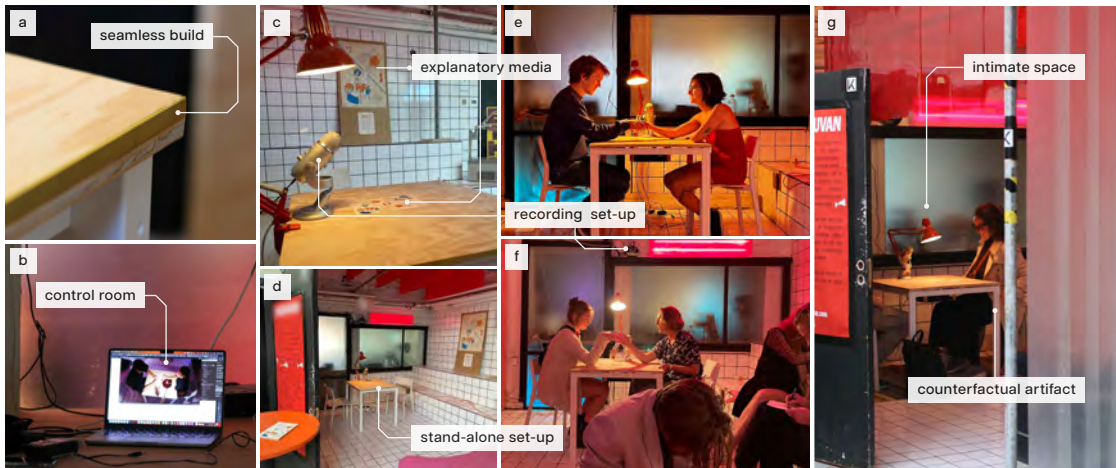


Figure 3.3: Annotated collage of the Undertable set-up and field study at Kolgruvan.

Shadows and, consequently, developed a different framing and sensibility? I would argue that the combination of a *dérive* and an artifact analysis – adapted to the topic at hand – could remain a constant and generative approach, particularly when working with things. It would be especially interesting to expand this methodology by incorporating an awareness of the entanglements surrounding things or complementing it with a relational mapping to capture their broader socio-material networks.

Balancing Familiarity and Strangeness

As noted in Paper III, the “tableness” (more on this in Section 3.3.1) of actuated tables remains a strong anchor for people to ground the familiarity of tables, even as actuation introduces defamiliarising qualities. Striking the sweet-spot in the tension between familiarity and strangeness is a balancing act that, when pulled off well, can make for an engaging design that catches people off guard and stimulates reflection mediated through the interactive thing. Figure 3.1 (d, k, and i) shows initial reactions on the participants’ faces after finding out the table responds to touch.

During the deployments of the various Undertable prototypes, it became an ongoing struggle to balance the subtlety to maintain an appearance close to an ordinary table – crucial to create a disruptive effect – and making it stand out enough for participants to engage with its interactive elements in the first place. For instance, in some environments the airflow under the table was too subtle to be noticed by participants, so we later decided to add a reactive lamp, making the response to touch more visible. This struggle eventually led to the development of the notion of ‘an odd invitation’, the Paper III’s theoretical contribution to Hoby’s [27] original design program of *Homo Explorens*.

The ‘odd invitation’ is essentially a calling for a more structured approach in developing an ecology of artifacts surrounding the Undertable. This was crucial

to facilitate a self-standing experience for participants to discover the estranged aspects of the seemingly ordinary table. In the Undertable, we achieved this by not only adding the reactive lamp, but also by putting in significant effort into designing promotional material, such as posters, information leaflets, and a dia-projector (see Figure 3.3 c, d), to attract people into an experience with the table.

While my research thus far has partially addressed the question of how everyday things can be remade through defamiliarisation, it remains an on-going inquiry. In the future directions (Section 3.4), I outline my ambitions to dive deeper into the topic by formalising methods for the defamiliarisation of everyday things and expanding the range of lenses through which defamiliarisation can be applied.

3.2 RQ2: What are the lessons learned from changing the materiality of tables through actuation?

In this section, I explore how the materiality of tables changes through actuation, drawing from insights in Papers I, II, and III. I categorise current applications of actuation, highlight its potential to influence social entanglements, and open a broader consideration of materiality, including immaterial and playful aspects based on the Undertable.

Current Forms of Actuation in Tables

Paper I points out a broad diversity of examples of how the materiality of tables changes when actuation is added to its material composition. The four actuation forms presented in the paper, sketch out an initial categorisation of different ways of actuating in tables in the current body of HCI research. Figure 3.4 shows the actuation forms: *actuated tabletop*, *mobile*, *height-change*, and *shape-change*, along with four design cases ([43], [44], [45], [7]).

The KirigamiTable [7] exemplifies *shape-changing* actuation, dynamically adapting its tabletop configuration between group and individual work. It transitions from a flat surface accessible to all team members to a folded, Kirigami-inspired arrangement that provides private spaces. ActiveErgo [45] demonstrates *height-changing* actuation, combining posture-sensing to optimize ergonomics for desk work. Sociabowl [43], a dynamic bowl at the center of a tabletop, showcases how an animate object can mediate social interactions, facilitating turn-taking among participants. Reviewing fifteen actuated table designs reveals that actuation in tables is often characterized by *adaptability* and *flexibility* in spatial arrangements, as seen in KirigamiTable and ActiveErgo, or by *social mediation*, as exemplified by Sociabowl.

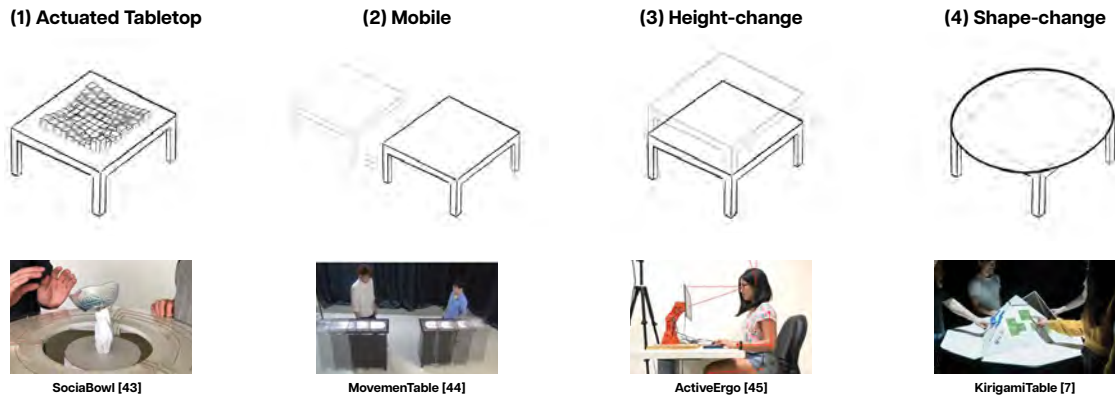


Figure 3.4: Illustrations of four actuation forms: Actuated Tabletop, Mobile, Height-change, and Shape-change. (Images are reproduced with permission from the corresponding authors)

Social Mediation through Actuation

The review demonstrates potential for social mediation, such as enabling turn-taking in meetings [43], [46] or encouraging an equal eating pace by adjusting the height of the plate based on how much food is left on it [6]. Seen through the lens of entanglement, this agency as a social mediator positions the table as an active participant in human interactions rather than a passive object. It is important to note here that these examples aim to “optimise” situations, such as the ideal ergonomic posture based on recommended ergonomic metrics, an equal eating pace, or delegating the word to someone who is more quiet during meetings. Whether these social behaviours exhibited through the actuating component of the table’s materiality is ‘successful’ or desirable depends largely on how the logic behind its materiality is pre-programmed by the designers. Here I see a risk in how technology as in the form of a socially actuating agent can diminish the complexity and nuance of social situations – landing in some sort of uncanny awkward feeling.

While most applications of actuated tables in Paper I address utilitarian purposes, Paper III investigates another form of actuation in tables to mediate social experiences – playful exploration. It’s logic is extremely simple and valueless: the only actuated ability it has is activating a set of air fans hidden under the table in response to people touching each other bare-skin. Here, the subtle qualities of airflow and electric conductivity are a part of the table’s materiality. The simplicity in actuation, combined with these immaterial materials, was just enough to act as an alibi for people to playfully explore skin-conductivity as a fascinating phenomena – placing the focus of interaction on the other person sitting at the table, instead of focusing on the table itself.

The following quote by a participant in Paper III illustrates this:

“I realise that more if I reflect on it [the value of touch]. [while trying the table] I wasn’t consciously thinking like: ‘OH! there’s

something going on' ...more on the surface level. And if you think about it more, talk about it, then you are like: "Whoa! it's actually very interesting — cool!" Or like... that's what it's doing — touch does that." (P11, Paper III)

Even though it is hard to isolate the effect of actuation solely, the experience of the Undertable as an actuated table in its entirety – including the strong concept from the Mediated Body [30], the defamiliarisation effect of hiding technological impressions, or carefully creating an inviting ambiance through the 'odd invitation' – it is evident how a change in materiality had a transformative effect on some. While some did not seem to be bothered by the table's strangeness, others went further to reflect on the meaning of touch. For instance, the following pair collectively discussed their current status of touch between another:

P1: *"I mean, it was different because like we are on "hugging level", we hug when we meet but that always feels less personal."* P2: *"Yeah, yeah, it's not skin on skin, as this was."* (P1 & P2, Friends, Paper III)

The inherent fascination of electric conductivity also stimulated curiosity in participants, often wondering what happened if they kissed:

P10: *"And then I thought: what happens if we kiss?"* [giggles mischievously] [P9 starts laughing] (P9 & P10, Strangers, Paper III)

Ultimately, for some, this table provided a 'magic circle' in which they felt comfortable to temporarily, while at the table, let go of some social norms. Participants began to break usual social norms, with even strangers touching in ways they typically would not. Friends, too, shifted their usual interactions. As comfort grew, they explored more unusual forms of touch, such as using their legs or even holding each other's noses or nose rings — a form of touch rarely seen between adults.

This thesis broadens the understanding of the materiality aspects in everyday things, using tables as a vehicle for experimentation. So far, I gave examples of how current tables in HCI use actuation, I discussed how actuation in tables gives the thing agency to mediate social situations – with my own case study on how actuation can be instrumental for playful exploration through a table. In future work, I aim to examine another lens of materiality – biomaterials. Also take inspiration from Paper IV to study how actuation in tables can lend itself to accessibility applications. Finally, towards the end of my PhD I wish to summarise these various lenses to revisit the current understanding of materiality of everyday things in HCI.

3.3 Findings During the Process

Beyond directly addressing the research questions, several insights emerged during the course of my PhD. These insights cover themes such as language as a lens for defamiliarisation and the development of design remakes as a methodology. While not directly related to the initial research questions, they contribute to a deeper understanding of how design research can challenge habitual perceptions and inspire new ways of engaging with previous work.

3.3.1 What is a table?

Frequently when I speak about my research work, whether it is at an academic seminar or a casual chat with friends, people are often energised about the absurdity of thinking of interactive tables. This sometimes takes a philosophical turn, raising the basic question: *what is a table?*

This section covers three language-related aspects of tables: the etymology of the word “table”, the generative potential of idioms and sayings about tables for concept-driven design, and the philosophical exploration of “tableness” as a quality imbued in objects through appropriation.

Etymology of Tables

I find it both amusing and inspirational how semantics of language and philosophising around a basic object as a table can be a consequence of my research. I see these discussions partially as a measure of success when seen through the lens of defamiliarisation. Such discussions are exactly what I try to achieve – people reflecting on something as mundane as a table and questioning the meaning of them.

Colleagues and friends who tried the Undertable prototype occasionally send me social media posts about interactive tables or social experiments that are mediated through tables. Some even researched the etymology of the word “table”, tracing its origins to the Latin *tabula*, meaning a plank, tablet, or list [47]. Interestingly, while *tabula* referred to flat surfaces used for calculation or record-keeping, the Latin word for a dining table was *mensa*, which also described a communal dining area [48].

Here we can see how tables are so closely entangled with social dining practices throughout history. Fast-forwarding to today, the meaning of the word “table” has now extended to the digital realm, referring to an arranged representation of data, typically in columns and rows. This definition comes again from the word “tabula” – a conceptual leap still tied to *tabula*, which once described physical surfaces for calculations. Similarly, in graphical user interfaces we still refer to a “desktop” on our computers as the screen-estate used to organise and store icons or files, echoing the physical utility of a table or a desk.

Idioms as a Driver for Concept-Driven Design

Tables have also made their way into language, appearing in the form of idioms or sayings like “taking a seat at the table”, “laying one’s cards on the table”, or “paying someone under the table”. Such sayings might give away cultural and historical associations with tables and their roles and uses in everyday life.

These idiom could be yet another lens to defamiliarise everyday things in relation to the first research question. In my work, I found it to be generative to try and analyse and extract the atmosphere or ambience of an idiom and using it as a source for creativity when doing concept-driven design projects. The Undertable is one example, trying to capture the covert and mischievous association from doing something ‘under the table’ and turning a similar sentiment into a playful experience.

Tableness

One of the most thought-provoking comments I received came from Dag Svanaes after presenting my work at the NordiCHI summer school, where he raised the question – drawing on Heidegger – of what constitutes the *tableness* of things?

According to Heidegger’s view on objects and tools, it is the use of the tool that gives the tool its purpose. Dag Svanaes showed us a video snippet from ‘2001: A Space Odyssey’ of an ape learning to appropriate a bone to crack a skull. This scene symbolises a key moment in human evolution where humans started to use objects as tools. Here, utilising the bone as what we associate with the use of a hammer, is what gives the bone its ‘hammerness’. In that example, it is very clear that a hammer has a singular use - to exert physical force on another object by swinging it using our body. When trying to define ‘tableness’ it gets arguably more complex because tables come with many uses and appropriations.

Probably the most common use of a table, and what gives an object its *tableness*, is to contain external objects, on the premise of having a physical material surface that is flat, solid, and horizontal. If it were soft, would it be considered a bed? If it were vertical, it could not hold an object due to gravity. Of course, tables are used for purposes other than holding objects. Tables are also used for people to gather around them, providing a certain support to lean on when standing, or delegating seating arrangements. Tables are also appropriated to serve as shelter during earthquakes by hiding underneath it. But does that give the table its *tableness*? I would argue not. In the latter case, I would say the table is given a *shelterness* instead, but the object remains a table since its primary purpose and therefore its association is to hold objects.

Perhaps a more relevant and more generative discussion for research and design-practice is to investigate how things can be given a *tableness* instead. During the *derivé* in paper II, to scout for tables in the city, we found several cases of where objects that were initially not built to be a table, were given a *tableness*.



Figure 3.5: Objects with a tableness: a spool (left), a tree trunk (middle), a road sign (right).

Figure 3.5 shows a tree trunk (middle) that we found in a playground with wear-and-tear revealing previous usage of tableness, and an empty spool on the pavement of a size and height making it a suitable candidate for tableness (left). The act of appropriating objects to be used for its tableness requires some creativity and imagination, as shown the example on the right where a road sign is repurposed for its tableness.

Future Explorations of Tableness

It would be worthwhile continuing the study of the semantics of tables from a designerly perspective, to further challenge and defamiliarise what a table is, its materiality, or the tableness in things, especially within the framing of entanglement. For instance, one could conduct a study using computer vision to explore how various datasets interpret everyday objects as tables. Here it would be interesting to explore how algorithms classify tables, for instance in proximity to other objects, whether appropriations of tableness will become visible, or whether tables are purely detected based on its form.

3.3.2 Design Remakes as a Methodology for Design Research

One of the core contributions stemming from Paper III is the development of design remakes as a methodology for design research. This has been a central focus of my research, stemming from an initial search for a design research equivalent to replication studies. I quickly realized that replication, as understood in other disciplines, does not align with the emergent and reflexive nature of design research. Instead, through Paper III, design remakes emerged as a suitable alternative, one that aligns more closely with the practice-based ethos of design research.

Strong Concepts as a Driver for Design Remakes

One of the main claims in Paper III is that the value of design remakes lie primarily in their capacity to generate new insights and expand upon existing theory by re-applying a strong concept (Section 1.2) within a new context. According to Höök and Löwgren, in order for a strong concept to earn its academic validity, it needs to fulfil the quality criteria of being *contestable*, *defensible*, and *substantive*. The concept needs to be grounded both horizontally

and vertically. Horizontal grounding refers to “relating it to similar concepts, focusing on similarities and differences that can help to understand the range of applicability of the strong concept.” and vertical addresses questions such as “Is the strong concept present in other known instances? Can we use those other instances as a broadened empirical base upon which to learn more indirectly about the strong concept in use and thus be able to predict more reliably how it can or will affect use?” [28].

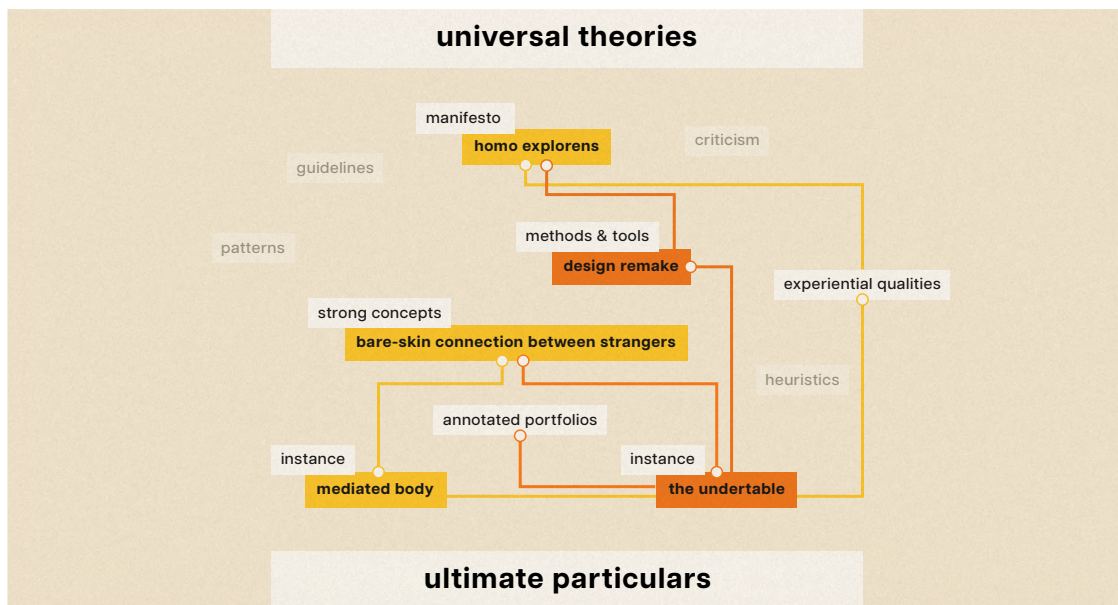


Figure 3.6: An overview of our methodology for the Undertable project. Adapted from Höök and Löwgren’s mapping of intermediate-level knowledge [28].

Reflexivity and Emergence in Design Remakes

I see an opportunity here for design remakes as a strong candidate for examining the strong concept against the quality criteria and its horizontal and vertical applicability by taking the concept and applying it in a new context. Applying the strong concept in different forms of artifacts, in a different environment, with different designers, and different participants, could be a fruitful way to engage more directly with previous design research. It does not only strengthen the rigour of design knowledge by expanding on initial findings, being able to compare, contrast, and expand the results, but could also be a way of revitalizing previous research projects through rebuilding interactive systems so they can be experienced by a new audience. Thus, design remakes embraces the reflexive and emergent nature that characterise design research [49]. This process enables design researchers to directly engage with prior work, not by replicating it exactly but by reinterpreting and adapting core ideas to discover their underlying principles and applicability. It is a form of citation to previous work – the design way – through hands-on engagements with the original work.

Figure 3.6 presents a graphic representation of the knowledge generation structure in both the original study of The Mediated Body [27], [30] and the

Undertable. This is one example of how design remakes can be used as a methodology to generate intermediate-level knowledge Höök and Löwgren. Both projects are *ultimate particulars*, different instances of the shared strong concept of establishing a ‘bare-skin connection between strangers’. Through our own design practice and the evaluations of the Undertable we could draw parallels and echo insights from the Mediated Body, and contributed a new theoretical aspect – the odd invitation – to the design program of Homo Explorens [27].

In line with Redstrom’s call for design research to create their own methodology innate to our practise-based nature [14], design remakes provide a way to experience and reflect on prior work through hands-on creation. This adds layers of understanding that are difficult to capture in written analysis alone. By engaging with a prior design practically, researchers gain embodied insights that can lead to richer interpretations and potential refinements of existing design theories or concepts, as seen in the research process with the Undertable.

For example, it was easy to relate to Hoby’s written descriptions of how the Mediated Body was engaged with differently depending on the situated context [27]. In his thesis, Hoby mentions:

“People would be interested in trying it out [at the conference], but after few sessions it became clear that the interactions were entirely different. They would try it out with almost mechanical precision. First initial touch, then prolonged touch, then a little play with aura. In the end, they would take off their headphones, take one step back and say something along the lines of ‘That’s nice — how does it work?’ The intimate engagements where participants would laugh and smile were replaced with examination and evaluation.” [27, p.141].

A similar contrast appeared between the deployments of the Undertable at Kolgruvan, a festive setting as a self-standing design without recruitment from the researchers, and the university library. At Kolgruvan, participants responded more spontaneously and genuine than when deployed in the university setting, where participants were more analytical and inclined to ‘solve the riddle’ by figuring out how it works – thereby bypassing the playful experience as intended.

Furthermore, similar to how Hoby [27] describes the aspect of ‘Performative Frames’, where participants would take on certain roles such as the ‘ambassador’, where someone who tried the Undertable before recruited two friends to – what we suspected – set them up (see Figure 3.1f). We also observed the ‘critic’, who tried to solve the puzzle of how the interactive concept works, draws their rational conclusion on the meaning of touch and returns back to their everyday business, and the ‘saboteur’ who decided to ignore the study and went on to eat their roll of kebab at the table (Figure 3.1e).

The Importance of Rich Documentation

This brings me to an important prerequisite for design remakes – the clarity and richness of articulating design work. For remakes to serve as a reliable basis for future research, the original designs need to be richly documented and made accessible. Rich documentation that captures an artifact’s nuances can be labour-intensive, and without it, remakes may lose alignment with their source material. We were lucky and grateful for Hoby’s extensive thesis, which provided substantial content to engage with – it provided some vital background stories that are often left out research papers. The videos were also inspiring, clear, and gave a glimpse of the experience that would be impossible to portray in words.

3.4 Future Directions

This final section outlines future directions for my research, building on the findings and concepts explored in this thesis. From developing frameworks to defamiliarise everyday things, to designing for accessibility and integrating living materials, these directions aim to broaden our understanding of how materiality in HCI can shape – and be shaped by – our interactions, routines, and relationships.

By revisiting the materiality of tables and extending these explorations to other everyday objects, I hope to inspire new ways of designing, caring for, and relating to the things that are usually taken for granted in our daily lives.

Defamiliarising Everyday Things

As already hinted before, one of the logical next steps would be to develop a more structured approach, framework, or method to defamiliarise experiences with everyday things in the light of concept-driven design. Paper III already suggests design remakes as a generative method to defamiliarise a table to create a playful experience. Paper II describes the habit or practice of looking under tables as a technique to prompt new perspectives on everyday things. I also discussed how we might use idioms related to everyday things as conceptual input for design. These can be more formalised and structured to make it easier for designers to apply such techniques to inspire design work or open up for alternative perspectives on everyday things and their entanglements.

This would likely contain similarities to the sequential structure of defamiliarisation as seen in Shklovsky’s *detach, wrest, turn* [32] and Wilde, Vallgård and Tomico’s *disrupt, destabilise, emerge, embody* [33], but with a specific focus on the thing itself. This would likely start with a form of artifact analysis to study the current qualities and entanglements of the thing in subject. This analysis could be expanded with a mapping of its entanglements, or a finding conceptual inspiration through the semantic connections in language (Section 3.3.1), going on a *dérive* combined with photography, probes looking at the object through a different lens while setting an intention beforehand.

The next step would be to disrupt or skew one of the variables or patterns to see what new perspective emerges. When it comes to redesigning the thing itself, the key challenge is, as seen in the Undertable, to find the sweet-spot between creating enough contrast to sufficiently make strange while maintaining a clear connection to its initial resemblance – e.g. keeping its “tableness”. This may be worth exploring with other researchers as a conference workshop.

Defamiliarising Accessibility – Evolving Everyday things Over Time

Another promising direction is exploring how defamiliarisation and actuation can contribute to accessibility. Building on Paper IV, this research could investigate how actuation transforms the relationship between people and assistive devices. Paper I points to a gap of accessibility-related applications of actuated tables in current research, despite its adaptive potential. For example, could an actuated table or other furniture adapt to a person’s evolving needs over time, fostering a sense of continuity and connection?

This approach could incorporate temporality into design, imagining furniture that “ages” with its user – adapting as their physical or cognitive needs change. Such artifacts might acquire heirloom-like qualities – such as patinas (Paper II) – evolving materiality over time while accumulating sentimental value. Projects like OIO and SPACE10’s *Updatables* [50], which use AI to redesign IKEA furniture that evolves with its owner, provide an intriguing starting point for such explorations.

Living Materials – Growing a Table

While the digitisation of everyday things allows us to live more comfortably and connected than ever before, it has also estranged us further and further from the natural world. There is a growing interest in HCI in more-than-human design [51], which de-centres the human and involves non-humans as part of the design ecosystem. One way of addressing this dissociation could involve designing everyday objects that actively foster a connection with nature. For example, could a table be grown rather than manufactured, integrating living biomaterials into its design?

Such a living table would not only exist as a static object but could invite people to cultivate or actively care for it, bringing the natural world a bit closed into the everyday. Unlike watering a houseplant that eventually blends into its environment, such a table could be an artifact that people spend more time around as an integral part of how they go about their everyday routines. Coupling the table with activities like dining, or using it to grow and harvest food directly from its materiality, could bring the natural world into everyday experiences.

This approach offers a new lens for rethinking the materiality of tables – a natural one, characterised by unique properties like *liveliness* [52] and organic aesthetics. For instance, mycelium could grow mushrooms under the right conditions, creating a living artifact with its own evolving expressions and needs. Such a table would not only transform how we interact with everyday things but also how we design, care for, and relate to the natural world through them.

Revisiting Materiality in HCI

We are surrounded by things – ordinary, unassuming, and deeply familiar. Tables are among these, quietly anchoring our daily routines, yet rarely given a second thought. They hold our morning coffee, host our celebratory dinners, or serve as the backdrop to quiet moments of study. As their materiality evolves, they become more than wood, steel, or code. When defamiliarised through re-design, they challenge our assumptions, inviting us to relate to them in new ways – no longer just as static furniture, but as interactive ice-breakers, playful provocateurs, or even as living participants in our shared spaces.

As this thesis comes to a close, I wish to take a step back and consider a broader understanding of what the materiality of everyday things can be in HCI – one that includes computational additions, ephemeral qualities, and even living matter. As a final step towards the end of my doctoral research, I would like to collaboratively revisit and expand the understanding of materiality in HCI. Inspired by Wiberg’s framework [10], I aim to leverage my PhD projects’ case studies and hands-on experience gained from working with various sorts of materiality:

- **Computational Composites:** Explored in Paper I, highlighting the intersection of digital and physical materials in actuated tables.
- **Immaterial Materials:** Shadows and ephemeral properties such as airflow and skin-conductivity, as discussed in Paper II and Paper III.
- **Living Materials:** Proposed in the biomaterials section above, emphasising materials that grow, adapt, or evolve.

Building on Wiberg’s original framework, this expanded version would not only broaden the understanding of materiality in contemporary HCI but also provide methods for analysing and generating concepts that engage with these evolving material dimensions.

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