co-Ability
Aligned arguments
for the dissolution
of a human “centre”

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by Renáta Dezső

A Dissertation Submitted to Doctoral School of Moholy-Nagy University of Art and Design Budapest (MOME DS) In Partial Fulfilment of the Requirements for the Degree DLA (Doctor of Liberal Art) 2016-2022
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Translation and proof-reading by Péter Lévay. To the best of my knowledge, all images and photographs featured here were created by András Ladocsi and Marcell Kazsik. Additional photographs of the codesign prototype testing were taken by me.
Book layout and cover design by Marcell Kazsik.

Printed in Budapest 2022
ISBN 978-615-5134-35-7 (printed)
ISBN 978-615-5134-36-4 (pdf)

Author: Renáta Dezső
Title: co-Ability
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Acknowledgements

Although five years might seem a long time to focus on a single subject, it actually feels like the beginning of the road. I assume the research I started in 2016 is a life-long process. Of course, this is not an individual endeavour, and this doctoral dissertation would not have been possible without the support, patience, faith, and knowledge of many people.
I wish to thank a large number of people:

First, I would like to give my most enormous thanks to the individual who have remained constantly supportive throughout the academic part of this process – my supervisor Ákos Lipóczki, who never ceased to impress me with his reassuring encouragement.

I want to thank the fantastic lecturers at MOME Doctoral school for all the lessons and projects I have had the pleasure to participate in over the past four years. You all helped me improve my work through engaging with scientific concepts, participating in workshops and programs.

The ever-efficient Júlia Gáspár who kept me on track, either administratively or personally coaching me throughout the whole doctoral process with her kind heart and attentive precision, humbleness, and generosity. I have had the pleasure to share this engagement and learning experience with my fellow doctoral colleagues, who also taught me a great deal of academic life on sharing our thoughts, worries, and views. I am thankful for the fantastic time spent together and looking forward to continuing it.

Luca Szabados for being the most exceptional and patient person I met, facing all my questions with a smile and deep attention for honest responses to all of them. I am grateful for your time, for being open to sharing your experience with me and sharing it with the world throughout this doctoral work. Your generosity and open-mindedness are fundamental in completing this doctoral work.

I am proud of the many collaborations with Csillagház Elementary school in Budapest. I want to thank all the fantastic caretakers and specialists I have had the chance to collaborate with and learn from, with special thanks to Anita Takár.

All my gratitude goes to my colleagues, their pioneering works, and the amazing conferences at Gustav ELTE Bárczi Gusztáv Gyógypedagógiai Kar.

Moreover, I am especially grateful to Pál Koós, who supported me along the way. My sincere thanks also go to Péter Lévay, who reviewed my English papers over these years. I asked him to go through this entire dissertation, and I truly appreciate all his feedback and corrections.

I would like to acknowledge the immense gratitude I have towards all the researchers, policy makers, practitioners whose works and writings I have drawn upon while developing this study. Finally, I would like to thank my family – first, my mom Lajosné Dezső and my brother Péter Dezső for doing their best to understand my projects and being enormously supportive throughout. I would not have survived without you! Thank you, everyone!

Abstract

To generate critical and new insights to our value system in human-centred societal challenges the experimental approach of Research through Design and the power of critical disability studies explores philosophical and strategic possibilities to understand the concept of co-Ability. I introduce the term ‘co-Ability’ rooted in the critical approach of posthuman disability studies outlined by scholars such as Rosi Braidotti (2013). It serves as a broad umbrella term under which we can reconsider the potentials of various entities (biological and artificial) enhancing the shared competence rather than dwelling on the oppressive nature of human-centred norms.

By analysing the literature review this thesis addresses the reflective symmetry in key elements between disability studies and design approaches, questions the validity of a homogenous human need and reflects instead on how co-design can become a driving fuel for generating possibilities.

Identifying how design helps to improve the experience of being human, and not necessarily the user experience of a disabled person in prosthesis design development highlights the constraints of seeing a prosthesis as a process instead of a product. To investigate through personal values and situated concerns, the research settled on a case study prosthesis development with discursive and self-reflective process. It actively contributed to a better understanding of embodied thoughts on relationships. With the methodological approach of co-design framework, I point to the junctures where technology, bodies, and cultural theory intersect in a decentralised soft assembly in which disability, technology, and design act as equal partners in determining co-Abled formations.

Absztrakt

Ahhoz, hogy új kritikai szemléletet tudjunk behozni az emberközpontú társadalmi kihívások által dominált értékrendünkbe a kísérleti célú tervezőművészet tudományosan vizsgált eszközrendszerét és a kritikus fogyatékosságtudományt hívom segítségül. A két terület egymást erősítve generál új lehetőségeket a képességek közösen létrehozott jellegének megértésére. Bemutatásra kerül a ‘co-Ability’ terminus, amely alapjai többek közt Rosi Braidotti (2013) által is meghatározott poszthumanista fogyatékosságtudomány diszciplínájában gyökereznek.

A rendelkezésre álló szakirodalmat elemezve a dolgozat mélyrehatóan foglalkozik a fogyatékosságtudomány és tervezői megoldások között húzódó szimmetriával. Megkérdőjelezi a homogén megoldások szükségét és előtérbe helyezi azt, hogy az együtt-tervezés (co-design) hogyan válhat egy új megközelítés hajtóerejévé.

Az értekezés azonosítja a tervezőművészet hogyan javítja emberi élet megélésének élményét a fogyatékossággal élő személy felhasználói élményének fejlesztésén túl. Így a kísérleti célú tervezés során a művégtagra nem egy konkrét termékként, hanem a kutatási folyamat részeként tekint. A kutatás személyes értékek és egzakt felvetések kibontása után egy olyan típusú közös képességeken alapuló művégtag fejlesztés esettanulmányának bemutatását tűzte ki céljául, amely rávilágít a felszín alatt rejtett történésekre a cselekvési folyamatokban. Az együtt-tervezés metodikai alapjait segítségül hívva rámutatok azokra a csomópontokra, ahol a technológia, a résztvevők, és kulturális teória összetalálkoznak és ezen decentralizált találkozópontokban egyenjogú partnereiként határozzák meg a képességeik közösen kialakított formáit.

Declaration of authenticity

Author: Renáta Dezső
Date and place of birth: 07.08. 1977. Budapest

This thesis represents partial submission for the degree of Doctor of Liberal Art at the Doctoral School of Moholy-Nagy University of Art and Design Budapest (MOME DS). I confirm that the work presented here is my own. Where information derived from other sources, I confirm that the thesis has indicated this. During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Budapest, January 2022

Theses

Research

‘Science’, ‘design’, ‘disability’, and ‘technology’ has a common aspect in being somewhat homogenous. Therefore they trespass the boundaries of categories, representing variation in methods and paradigms in the shared common cultural everyday space. Doctoral research with a single researcher in such a subject allows the freedom to develop an exploration led by the analysis of theoretical concerns, engaging in dialogue with design practice, focusing on main questions from a particular single case study project the pressure of developing or commercialising a terminal design product.

Design + Disability

The ethical and political dimensions of design for disability do not necessarily affect the user experience of a disabled person but instead help improve the experience of being human. The reflective symmetry in key elements between disability studies and design approaches questions the validation of a homogenous human need and thus reflects on how co-design can become a driving fuel for generating new possibilities. The discourse of design for social innovation combined with the nature of design, and the criticality of craftmanship in the ‘maker movement’ with the social situation of disability predominantly attempt to reform everyday life culture and offer changes for the conceding relation between society and market.

Prosthesis

The competition among medical device manufacturers in the healthcare industry establishes segmentations based on monopolised policies linked to techno-centred know-how of a product often on the global market scale. These medically specialised objects combined with novel technologies are mainly unaffordable without governmental help or charitable associations, and ‘the clients are rarely seen as customers because they neither paid for their equipment nor had a major say in the choice of the equipment purchased’ (Dezső, 2019).

With a prosthesis functioning as a social symbol and a political emblem for oneself, the distinction between aesthetics and usability is blurred. Indeed, the form of a prosthesis does question the bio-normative body model and also question the necessity of an artificial interpretation of a biological limb. The tangible material condition of the prosthesis prototypes provides the possibility of operating with a set of ‘boundary objects’ within design discussions which include latent perspectives carried out.

Co-design + co-Ability

The framework of situated research in the design discourse closely connected to disability studies maps out and builds up a view of co-Ability. The discursive co-design process with the active contribution of a person with a disability leads to self-reflections also on my part as a designer. The tangible material conditions of digital craft are considered a process rather than a product, which leads to understanding why design is more than an interface between a material object and its use.

The relationship between ‘head’ and ‘hand’ + ‘materials’ and ‘tools’ manifest themselves in the context, instead of bilateral symmetry critically address the transversal form of understanding the bond that connects them.

Outcome

When disability is not taking part in communicating design excellence in the power of care, it cooperates to represent substantive ideas with topical complexity of disability that is more relevant to individuals and the general public. In this view, discursive prosthetic design appearance carries a deeper, more integrative argument that is significantly connected with the general viewer and represents the theory development. The data of the artefacts constructs the evidentiary values. The digitally crafted prosthetic prototypes encode a tangible chain of thoughts with a result of design synthesis of knowledge and research question with the central links of the method.

Tézisek

Kutatás

A tudomány és a fogyatékosságtudomány, a tervezőművészet, és a technológia legkisebb közös nevezője önnön homogenitásukban rejlik. Mind a négy fogalom a tradicionális kategóriákon átívelő jelentéssel bír, emellett folyamatosan változatos metodikákat és paradigmákat képviselnek mindennapjaink kulturális terében. Emiatt ezen területek kutatásában igen nagy szabadságot élvezhet az ember: jelen doktori értekezés megírásához szükséges megvizsgálni az elméleti aspektusokat és a tervezési folyamatra dialógusként tekinteni. Mindez segít választ találni a legfontosabb kérdésekre egy egyedi tárgyfejlesztési esettanulmány szemszögéből miközben a kutató vállait nem nyomja egy piacképes és eladható termék létrehozásának terhe.

Tervezőművészet + Fogyatékosság

A fogyatékosság kapcsán a tervezői munka erkölcsi és politikai dimenziói nem feltétlenül a fogyatékossággal élő személy felhasználói élményének segítését célozzák meg; sokkal inkább a teljes értékű ember megértésének erősítése áll a központban. A fogyatékosságtudomány szakirodalmának alakulása és a különféle tervezői megoldások között húzódó párhuzamos tendenciák alapjaiban kérdőjelezik meg, hogy létezik-e egy homogén emberi szükséglet a mindennapi élet területein.

A következő tényezők kulcsfontosságú szerepet játszanak abban, hogy mindennapjaink megértését megváltoztassák, illetve hatást gyakoroljanak a társadalom és a piac közti egyenlőtlen viszonyra: az alkotói szemlélet és folyamatok kritikai jellege; a fogyatékosság társadalmi megítélése; valamint a társadalmi innovációért létrejövő szituációkban megjelenő tárgyak természete.

Művégtagok

A különféle orvosi segédeszközöket gyártó cégek közti verseny olyan monopol vezérelt, technológiaközpontú irányelveket hoz létre, amelyek globális szinten szegmentálják az egészségipart. Ezek az orvosi segédeszközök gyakran a legújabb technológiai újításokkal ötvöződnek, ennek hatására a költségek emelkednek, így a legtöbben egyszerűen nem engedhetik meg maguknak ezen tárgyak megvásárlását a kormány vagy önkéntes szervezetek segítsége nélkül. “A felhasználókat nem igazán tekinthetjük vásárlóknak, hiszen, egyfelől nem fizettek a segédeszközért, másfelől nem választhatták ki a számukra leginkább megfelelőt (Dezső, 2019). Ebből adódóan a direkt felhasználói visszajelzések a vásárlás folyamatában nem láthatóak és nem hatnak a fejlesztésre.

Egy művégtag egyszerre hordoz társadalmi és politikai jelentést az egyén számára, emiatt az esztétika és funkció között húzódó vonalak hamar összemosódnak. A megszokottól eltérő protézis látványa alapjaiban kérdőjelezheti meg az álltalános testkép normatív jellegét és ehhez viszonyított hiányzó testrész mesterséges esztétikai pótlásának mibenlétét. Ugyanakkor, az újszerű művégtag prototípusok megérinthető anyagi természete testhez kapcsolódó ‘határobjektumok’ formájában az emberi képességek kereteit új perspektívába helyezi.

Együtt-tervezés + képességek közösen létrehozott jellege (Co-design + co-Ability)

Ezen kutatás keretei a kísérleti célú tervezőművészet tudományosan vizsgált eszközrendszerét és a kritikus fogyatékosságtudományt hívja segítségül ahhoz, hogy a képességek közösen létrehozott jellegéről átfogó képet kapjon az olvasó. A diskurzív közös-tervezés jellegének köszönhetően egy fogyatékossággal élő személy észrevételei tervezési folyamatot meghatározóan befolyásolják. A létrehozott megérinthető digitális alkotások közvetlen visszahatása az együtt-tervezés folyamatára eltávolítja az értelmezésüket a piaci termék kategóriától. Ezen komplex egymásra hatások segítik megérteni, hogy a tervezőművészet (design) nem csupán közvetítő természetű a tárgy/termék és annak felhasználhatósága között. A ‘fej’ és ‘kéz’ vagy a ‘matéria’ és ‘eszköz’ kontextusban a kapcsolódás komplexitása bemutatja a párhuzamos szimmetrikus formációkon átívelő hálózatos összeköttetéseket.

Kutatási eredmény

Amikor a tervezőművészet (design) nem a segítő magatartásban rejlő erejét és kiválóságát társítja a fogyatékossággal, hanem a fogyatékosságban rejlő komplex dimenziók és kapcsolódások megértésében működik együtt az relevánsabb hatással lehet a társadalom egészére és az egyén mindennapi életére. Ebben az értelmezésben a diskurzusokon alapuló társ-tervezés érvei direkt jelleggel integrálódnak a létrejövő objektumokba, így a művégtag prototípusokban az álltalános közönség számára bemutatható nem verbális módon megjelenik az elméleti okfejtés és annak fejlődési folyamata. A kísérleti célú tervezőművészet tudományos bizonyításának adatai a tervezett tárgyakba épülnek bele. A digitálisan megalkotott prototípusok magukban hordozzák a gondolatfolyamatot, ezáltal pedig egy materiális tudás szintézist hoznak létre, amelyben a kutatás központi problémája ötvöződik a metodika magjával.

Chapter I.

Establishing the research territory

In the first chapter, I will establish the research territory by situating the parameters in the context of co-Ability. In this chapter, the intention is to define the transdisciplinary fields of studies and the related connections within these disciplines, present my professional background leading to the initial thought and intentions, followed by analysing the articulation of the problem. Moreover, my aim is to present the research questions and assumptions leading to the hypothesis and to present the limitation of the study by exploring the lines of questions why, what, where, when, who, how this design research is established. At the end of the chapter, I define the terms appearing in this text and describe their understanding in the context of this study.

Introduction

The objective of this work is to raise crucial issues that designers should be aware of at a time of great challenges of anthropocentric societies. The novel research approach is supported by social science and an engagement in the form of implicit conceptual work that distributed important points and questioned human-centred normative visions of our world. This study brings potential insights to the topical, procedural, pragmatic, and conceptual articulations of co-Ability. The research contributed from a disability studies perspective combined with design culture to offer alternatives for the dominant 'humanist normal man' (Braidotti, 2013). The narrative of the dissertation is not linearly arriving at the discussion of co-Ability as the word appears before it is explained in detail and returns all along with the essay. I present the organization of the dissertation in four main sections.

First, I establish the framework of the doctoral research by representing my professional background and the initial intention with a caring attitude(Jones, 2013). My initial core question was centred on inclusivity and transitive practice with a caring attitude, which appeared in the area of the internal operation of the prosthesis and human interaction, such as timing, function, mechanical needs and cost-efficiency. The initial thoughts invited to combine technology, digital crafting, disability study, and problem-solving for prosthetic development. During this early period, much time was spent on understanding what can be an act of greater caring in the design industry than creating a personalised prosthetic for a person with a disability. Affected by the personal perspectives during the case study, the initial selection of questions were repositioned at another point in the framework, raising new ideas questioning the normative symbol of the material object instead of the inclusion of people with disability. Under the influence of critical disability studies, the role of a designer in the 'design for care' situation shifted towards being an interpreter of messages and semiotics. Furthermore, the last section of the first chapter is dedicated to terminological issues and detail-related concepts that are central to the discussion in this dissertation.

In chapter II. I present the literature review of critical disability studies inviting posthuman studies and reflecting on design culture that has developed in association with disability politics. I present the contrasting accounts of universal design and rehabilitation engineering in parallel with the pathological approach and a political view of disability, questioning market pull strategies and technology-pushed processes. The comparison suggests that the normative attitude of the traditional design strategies is not compatible with the reflections in the prosthesis design case study presented in the third chapter. Nevertheless, the second chapter discusses connections and background in the contemporary disability culture of Hungary, Budapest, and some local studies and educational programs are also conducted as part of the research. At the present time, designers can no longer be viewed as individuals who create objects for the healthcare industry but as conveyors with convincing arguments by means of a new synthesis of objects and words in shifting focus on disability issues. This research also seeks reflection on the designer's position in art science and society, as already Buchanan argued, "to discover new relationships among signs, things, actions, and thoughts is one indication that design is not merely a technical specialization but a new liberal art" (Buchanan, 1992).

As mentioned before in the third chapter, I draw out fundamental features in the case study design work that gives co-design theories a provisional and possible aspirational method to work with. In the third chapter, with the insights gathered from the mixed methods of case study experiment and digital craft, I use participatory observation and self-reflective observation to suggest that the development of prosthesis created with collaborative design practice should target not only methods of solving design problems but also informal and social interactions in the posthuman collection. Rooted in the presented theoretical analysis in the second chapter, I explore the aspirational theory of co-Ability grounded in critical disability studies and posthumanism. This methodological chapter provides output for the novel method in the research process that helps us further explore the way we use bodily information as well as the mode our brain encodes our greater shared understandings based on our self-recognitions grounded in Neuropsychological science. An understanding of both the scientific and the phenomenological details of embodiment also means exploring the ways the different modes of somatic consciousness can be related and collaboratively deployed to improve the representation of the self. The output of co-Ability leads me to survey the way we use bodily information that also determines how bio-techné encodes our greater shared understandings in human life. While the framework of the research situated in the design discourse is closely connected to disability studies, this text maps out and builds up a view of co-Ability. The text also attempts to locate aspects based on the continuous self-reflectiveness on the research itself that might offer an arena for further material and critical debate on design research.
Lastly, in the fourth chapter, I conclude the dissertation by reflecting on the dichotomous interactions between scientific research and artistic practice interplayed as the forces of a driving engine of the study.

Background & motivation

Four years ago, I started my doctoral research at Moholy-Nagy University of Art and Design – the same university I had studied at more than a decade earlier. Over that decade, I worked and survived in various design fields: I continued learning by practising design which I feel fortunate about. At the same time, I often missed the possibility to dedicate time and resources to understand problems interconnected with human experiences. Instead, I focused on short, market-ready product solutions oppressed by the corporate economy.

Understanding my main interest in examining, analysing, questioning, and challenging situations, issues and information were not a clear path for me. If I look back on the journey that led me to this point, everything makes sense, and the dots are connected with the hope that there is a lot more yet to come. I didn't know what really interested me and what I was good at back in elementary school. As I was afraid of public speaking and oral exams in general, I applied to a nursing high school to get an easy workaround. Although I never worked as a nurse, it was an excellent experience to learn anatomy and the pathology of the human body, giving me a great deal of understanding medical definitions with Latin origins. The human body has always amazed me: the drawings and visual representation of the body made me wish to understand how it functions internally and how it is perceived externally by others. My journey led me to concentrate on the perception of everyday life as a makeup artist. The most amusing thing about this profession was to change the illusion of a face or body part by using material camouflage on the skin. Creating an optical illusion by repainting the image of the body changes the perception of a person. I learned from the best in Hungary, and by winning a Hungarian national competition, I could also finance the tuition fee of entry preparation for the design university, which is now named Moholy-Nagy University of Art and Design.

At this point, I finally knew what I wanted to study. At the industrial design department, I learned about objects surrounding the human body and some interactions within the material environment. Furthermore, in the early 2000s, I also met early computer-aided technologies. It was a new area of computer technology with limitations. My Erasmus scholarship at Universität Duisburg-Essen, with the supervision of Stefan Lengyel, the head of the design department, further inspired me to submerge myself in the digital space. Learning digital tech went smoothly most of the time: I picked up 3D modelling without any frustrations.

After graduating in 2003, I worked in many different parts of the design spectrum. As a digital design specialist, I could learn various aspects of design methodology from established professionals in each area. During my five-year experience in Italy, I had the chance to work in Naval design as a CAD modeller and at an exhibition design specialist company to prepare planning, visual rendering, and implementation.

Also, I could investigate the creative craft of character modelling and character animation in the media industry. Although I had fun gaining various professional experiences in the immaterialised world of virtual design, I missed real-life design experiences, the craft of actions and materials of everyday life. At that time, the digital world and the material

Figure 01: 2003 graduation project for a university degree in furniture design at the Industrial design department

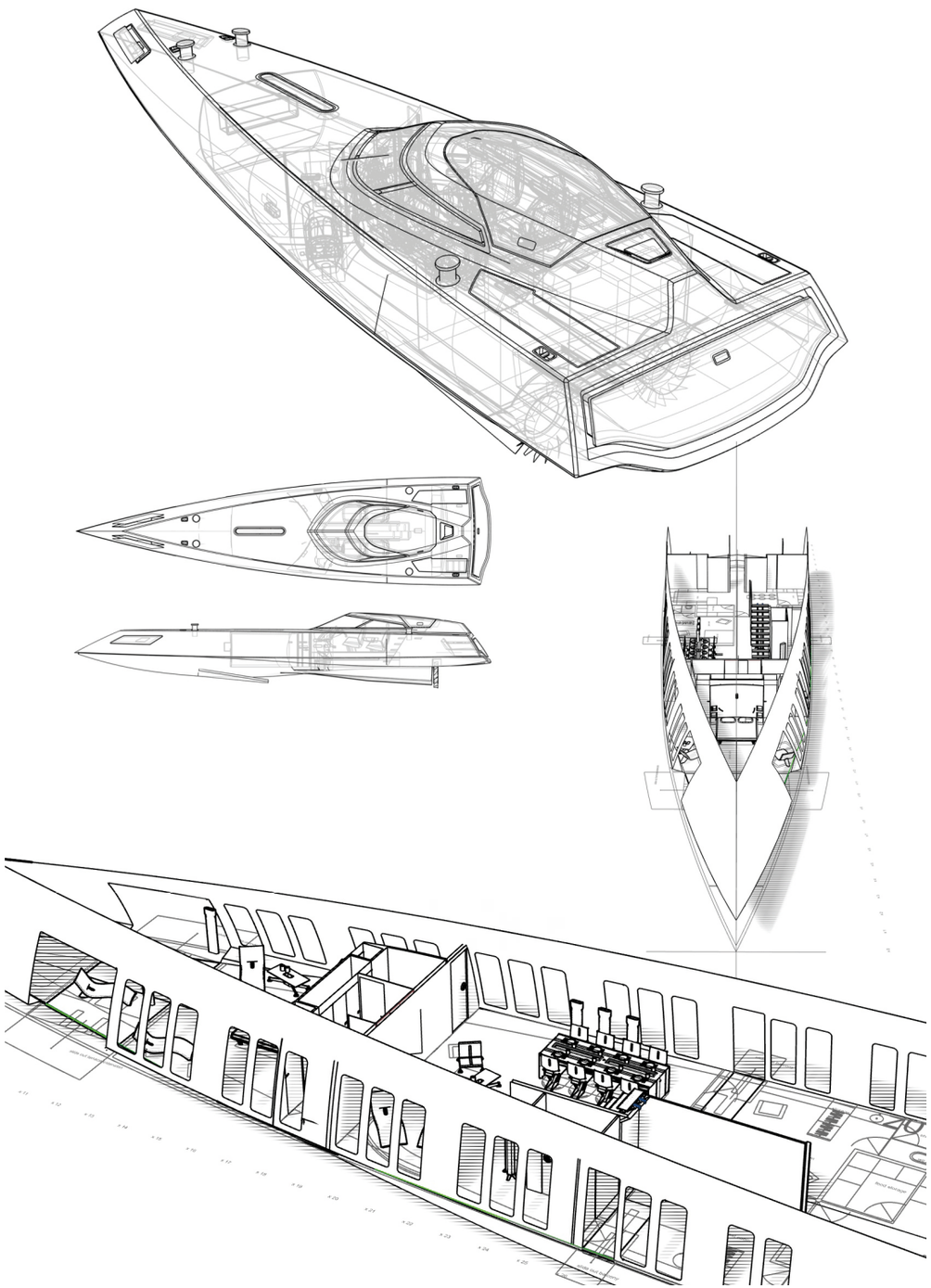


Figure 02: Naval Design 3D Artist Designer works for IF design in Italy, Torino.

analogue reality was hardly connected. Working with computers as a digital designer meant a lot of sitting in front of a monitor that narrows the encounters with the situational contexts of everyday life. Participations in physical situations are the undeniable tools for me to progress, move in space with my body, and interact with all the elements in the surrounding environment constantly teaches me.

In order to exchange the digital data directly with the real world, I explored Video Projection Mapping to create a physical illusion of physical structures in space. It was a unique yet short-lived experience in collaboration with Bordos Artworks. We worked on several international projects projecting dedicated animation onto national architecture.

My main interest in these works was to explore the optical and perceptive illusion of how the projected animation changes the perception of an environment. I created moving digital data with contrasting tones and minimal design to bring additional meaning to the subject by animating the surface of jewellery design (International Group Exhibition at Schmuck DE. Munich, title: 'What is in frame?', with contemporary artist Gisbert Sach and Réka Lőrincz), and interior environment (VLS Video Mapping Trophy Paris Heavent Centrum final show). Although these computerdriven, three-dimensional physical interfaces allowed the interconnection between real-world data and digital data, the aesthetic experience was mainly visual. Also, I still missed the physical aspect of the creative process. I craved for tangible, real-world experience interconnection with the digital one. As a solution, I learned a new technology called 3D printing and later 3D scanning. These technologies widened my design knowledge by 'reuniting visual thinking with manual dexterity and practised knowledge' (McCullough, 1998). Digital fabrication combined with Computer Aided Design (CAD) has transformed methods in my design practice and rendered me to the position of becoming a 'designer-maker', directing me into the world of craft practitioners. This transformation did affect not only this doctoral research, but also my present teaching experience as a head of the Object making bachelor program at the Designer Institute of MOME. The cognitive processes involved in teaching appears to be beneficial to research and creative practice; but interaction with students proves to be equally important (Bennett et al., 2010).

For the first four years while learning digital crafting, I immersed myself in the physical workshop of a start-up company. I enjoyed the practical apprenticeship and learned the technology from a skilled, young generation of mechatronic engineers. 'Since 2010, 3D printer technology has shown explosive growth with the help of the open-source and DIY communities' (Kamran and Abhishek, 2016).

In this expansive period of learning digital fabrication, I also experienced the sharing attitude of open-source movements that fuels the interconnectivity in this revolutionary field from early on. Working with the relevant 3D scanning technology also changed my view of how I see interoperability between real-world data and digital data or, in other words, 'the flow between the analogue language to the digital language' (Doyle and Fraser, 2019).
Following this, I engaged in many design processes focussing on market-ready developments that utilise the technology. I started to crave to add the cultural perspective in this early period of highly engineering-focussed design processes. I realised the time that needs to be dedicated can hardly be supported by a developing start-up company trying to survive in the commerce market.

That is how my design exploration journey led me to start the doctoral study with a core interest in understanding the human body concerning objects and the interconnected world around. This journey through industrial design, media design, artistic practices in the virtual world, and digital crafts have lent me an extensive toolbox of methods and techniques for design. I could learn the interoperable cycle between digital and analogue design processes with the interwoven reality that can be explored from every angle.

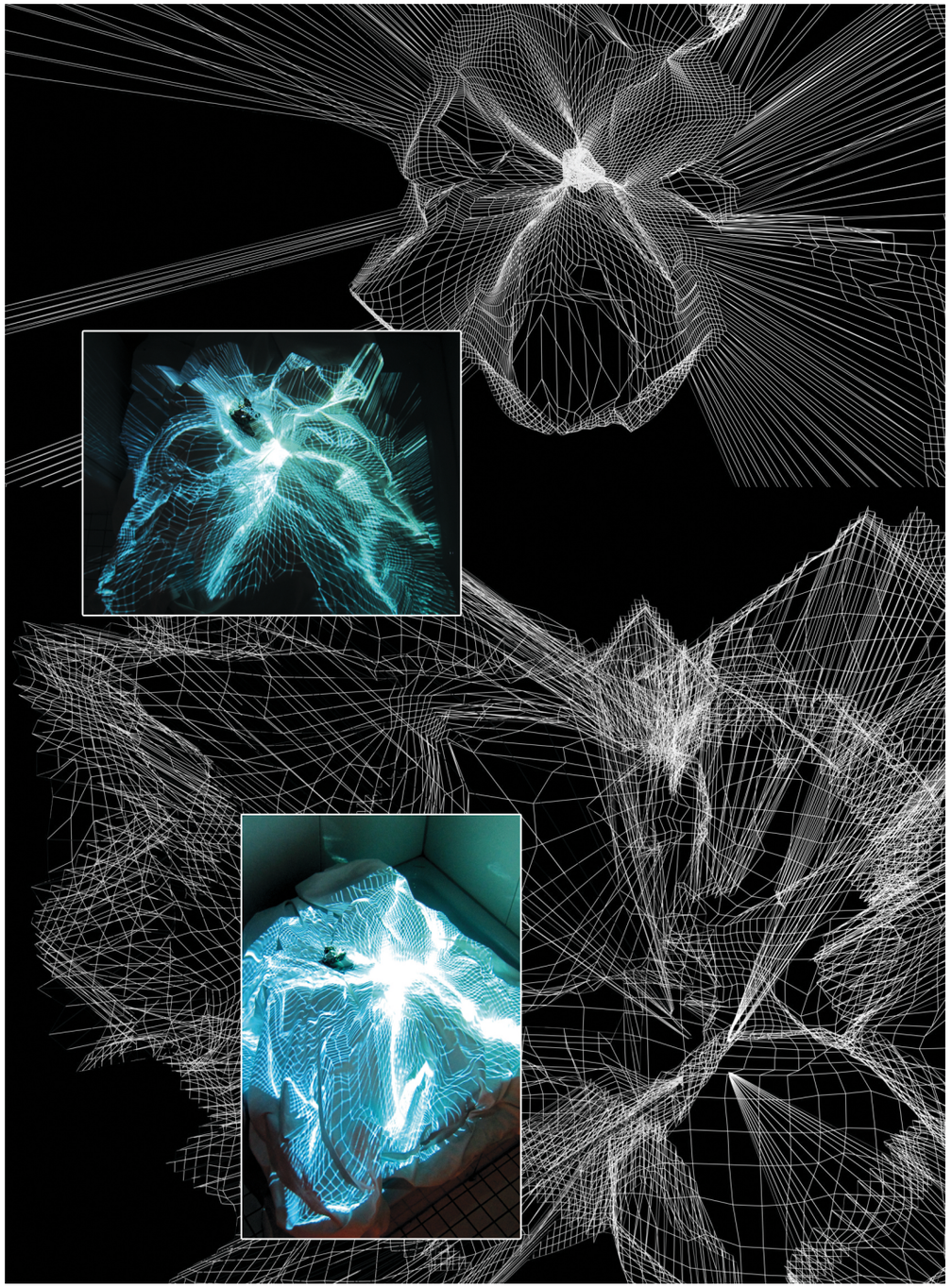


Figure 03: 2011 International Group Exhibition at Schmuck, Munich. Jewellery titled Soldier Boutique bracelet by Réka Lőrincz & Stach Gisbert, video installation Renáta Dezső.

Initial objectives lead to context

Technology itself is not a product

The initial objectives were based on my earlier digital design experiences with an interest to explore how technological invention can affect creative innovation. The term 'Design' should be considered broadly. In this dissertation, the digital design process is described as a range of technologically mediated activities of production employing labour involving the conception, planning, and production of artifacts, including images and objects. Lately, the widely available desktop-additive technologies have been forming the design process. Fast prototyping allows to switch the testing phase earlier in the product development process and therefore helps generate a quicker feedback cycle that eventually leads to more innovations.

My preliminary hypothesis suggested considering material conditions of digital technology as a process instead of a product supported by the theory of philosophies concerning historical materialism and sociologies of material culture (Dant, 2005). My primary goal was to present the 'method of grasping the relevance of human work and technology in the development of production and society, in opposition to the typological and cultural-historical view that formed the mainstream.'(Lull et al., 2013). In the present time, when technology pervades our everyday lives, the importance of such understanding is multiplied.

> 'The starting point for a materialist concept of history is the rejection of preeminent ideas, in the first instance of the idea of God as a vehicle of realism. Consciousness, thoughts, and beliefs are considered the results of specific material conditions in the human mind and not the active subjects of history.' (Lull et al., 2013)

At first, I draw out a research project with an interpretive approach in digital fabrication design, ranging from specific digital craft techniques in order to create classification in artefact taxonomies. In doing so, I am navigating within the frame of descriptive reports of phenomena to prove that design is more than an interface between technology and use. To be more specific, the initial choice of technology within the large spectrum of rapid prototyping, known as additive manufacturing, was the desktop 3D printing that melts a solid thermoplastic material (filament) and then deposits this filament (Fused Deposition Modelling, or FDM). By making it possible to complete a model in a single process, these 'desktop robots' practically act as game-changing devices while they carry out an economical manufacturing process with a final product. The cost-efficiency in object production for single object creation or personalised production is one of the most convenient characteristics. Comparing it to the vastly used injection moulding technique, the production cost for a single object makes a major difference. 'The fast growth of this technology has allowed great inventions and 3D printing (mainly Fused Deposition Modelling or FDM technique) reduced the cost of manufacturing, the build time, and the weight of the object, reduction of waste compared to some traditional manufacturing processes therefore making 3D printings attainable to the average consumer' (Kamran and Abhishek, 2016). In other words, selecting the initial technology based on knowledge gained earlier led to focus on the novel character of the created objects and adaptability. Additive manufacturing allows us to differentiate every individually produced object in size or proportion while the general design and the purpose of the created object remain static.

In the preliminary hypothesis, I considered the body-object interaction in design territory where a singularly-produced, personalised object with cost-efficient production could mostly be preferable. Designing the personalisation of an object also affects emotions and cognition. In order to explore these changes in a research project, there is a need to understand the modalities of interactions.

> 'Cognition and emotion cannot be separated. Cognitive thoughts lead to emotions: emotions drive cognitive thoughts. The brain is structured to act upon the world, and every action carries with it expectations, and these expectations drive emotions. That is why much of language is based on physical metaphors, why the body and its interaction with the environment are essential components of human thought' (Norman, 2011).

Based on Barsalou's and his colleagues' perceptual symbol systems theory (1999), different modalities are involved in interaction with our environment. Partial activation or simulation of the varied systems like cognitive systems (e.g., attention and language-processing), sensory systems (e.g., vision and olfaction), emotional systems (e.g., fear and pleasure), and less-studied systems such as motoric or kinaesthetic, and proprioceptive systems (e.g., grasping, manual manipulation, and internal feedback from muscles and joints) are fundamental to concept formation and processing (Tillotson et al., 2008). The materiality of digital manufacturing technology shifting us towards a certain hybrid 'Mechanodynamical' Age when a mapped experience leads back to new dynamic goods. In a way, the 'implication of the increasing immateriality of post-industrial technologies and the disappearance of computers is a return to things.' (Mazé, 2007). In other words, the Information technologies that are multi-functional, configurable, updateable, and disposable accommodate us towards the need to have the same dynamics in mechanical technologies.

While considering that every single human body is different and unique, it is easy to accept the practicality of the standardised measurements in our society. Generally speaking, a biological organism such as the human body is dynamically adapting to the environmental situation by "the evolutionary process whereby an organism becomes better able to live in its habitat" (Dobzhansky et al., 1968). In light of such implications, the research focus was narrowed down to situations where the design should consider unique and personalised solutions for the interrupted dynamics of adaption in the sensory and motor knowledge gained via bodily experience. Therefore, I looked for a specific design territory, namely prosthetic design, which improves body-environment interaction and where personalisation and cost-efficiency are preferred. Indeed, I started by defining the 'Design for Care' (Jones, 2013) attitude to support body-object interaction by bringing in the unique aspect of 3D printing technology to support body mechanics. As such, the initial idea concluded in mapping out and building up a preliminary view of the intention of an Exploratory Research to analyse body-object interaction and human-technology cooperation for the development of prosthetic production in a case study.

Statement of the problem

From problem-solving to problem-seeking

Identifying the nature of the problem in prosthesis design development highlights the constraints that would yield a solution.

However, certain successful concepts already exist in prosthetic design, and the most common approach follows the top-down development logic rooted in the positivist attitude in technological science. Traditionally, it has been associated with an approach that sees technology combined with the medical view having the necessary objectivity with deductive reasoning methods to seek prosthetic solutions. The positivist view of science is heavily criticized by social sciences in general; they question the social construction and emphasise the importance of subjective understanding of a personal experience. Today's most founded and popular prosthetic design developments originate from the post-war paradigm of mass production on 'goods' with advanced technologies, which have lately shifted towards mass consumption aligned with the current post-industrial production of experience. There are numerous varieties of positivism – in this dissertation, I use the term that represents the central assumption on a scientific vantage point is to narrate the world only objectively with representative data, which can lead to decontextualizing the subject itself. As many great design theoreticians described, in the shift from the industrial machinery of the Mechanical Age to the dynamic technologies of the Information Age, primarily experience was getting more focus than the actual goods (Jameson, 1992; Margolin, 1989; Margolin and Buchanan, 1996; Miller, 1987). Vardouli (2016) argues, just like David Seamon, that positioned phenomenology in the opposing pole of positivist research is concerned with the exploration and description of the human experience, and action (1987, p. 6). "From logic, research design, and statistical methods to assure clarity, objectivity and verifiability," he remarked, "the phenomenologist has only the dedicated wish to see thoughtfully and fully" (Seamon, 1987, p. 7, Vardouli, 2016). In terms of the Transhumanist enhancement, the prosthetic brought to life by advanced technology produces altered environments, service ecologies, and user experiences vision for the future instead of creating affordable objects in response to current personal problems. 'As persuasive design and the sociology of technology reveal, design is a powerful force in determining what might be – and what should be. It is inevitably ideological that design involves choices about the ideas to be extended into use, inscribing these in the spatial and temporal form of things that become incorporated into lived experience and cultural memory.' (Mazé, 2007). It also keeps the ideals of functionalism, standardisation, and the universal tendencies of the modernist International Style advanced by corporate capitalism. These ideals reflect not only on object use in design but also on expectation from a 'normatively' functioning citizen in a built environment. Meanwhile, in response to extensive material and critical potentials, contemporary solid theoretical and practical tendencies are abstracted into patterns for future predictions. In addition, the so-called 'post-industrial' technologies and DIY strategies from the bottom-up resonate with preferences in contemporary critical thoughts. The technological change from industrialisation to post-industrialism runs parallel with the shift from modernism to postmodernism. 'Proponents celebrated the potential of narrative and affective techniques enabled by 'humanware', 'softecnica', and 'dynamic images' – rather than static objects – and vernacular, 'undesign', and 'continuous redesign' – in place of design' (Mazé, 2007).

Suppose we consider the prosthetic as not merely a 'product' and shift emphasis onto the 'process' instead. In that case, the entanglements in disability and design history will clear up, and thus it makes the articulation of problems more manageable. 'In these circumstances, designers would no longer be viewed as individuals who create objects for the healthcare industry, but as communicators who seek to discover convincing arguments by means of a new synthesis of objects and words' (Dezső, 2019). When we focused on developing a personalised prosthetic for a specific individual in a case study project, the rhetorical expression of visual appearance undoubtedly gained primacy on 'meaning', and consequently, it questioned the ethical and political dimensions. 'Soon the initial selection of questions in the design method was repositioned at another point in the framework, raising new questions and ideas considering the normative symbol of the material object.' Such as: 'How does design help to improve the experience of being human, and not necessarily the user experience of a disabled person?' (Dezső, 2019). In theory, objects may be reduced to mere props in personal meaning-making, as touchpoints in the network society, or as by-products of systems of signs. The case study of prosthetic development yields design guidelines and best practices that informed researched theories (Gregor et al., 2007). My role as a designer under the influence of Critical Disability Studies shifted towards being an interpreter of messages and semiotics on questioning existing values. The research experience aligned with Ramira Mazé in Occupying Time: Design, technology, and the form of interaction imply that the concepts of 'becoming', 'in the making', and 'futurity' might be studied in hindsight. 'Such processes might be studied retrospectively, or abstracted into patterns for future predictions, much of what happens is beyond the scope and scale of discrete objects, individuals, or interactions' (Mazé, 2007). However, value is also a cultural, historical, and political matter, and technology changes the 'material practice' timing. The dynamics in the temporalities of an artefact (prosthesis prototypes) change the formation of 'participatory practice' by inviting interactions and the effects of 'critical practice'.

Scope and limitation

Why –

"To discover new relationships among signs, things, actions, and thoughts is one indication that design is not merely a technical specialization but a new liberal art" (Buchanan, 1992). The research starts with prosthesis development as a tangible, pragmatic procedure developed with positivist certainties in digital technologies for inclusive and transitive design showing a caring attitude. The reflections on the prosthetic case design study invited literature reflection on critical disability studies. The argumentative development process of the object in the co-design method leads to a prosthetic arm that does not follow the anatomical shape of a hand. Rittel and Webber suggested considering 'wicked problems' in contested social issues that are complex and fragmented; therefore, they could not be 'tamed' through standard rational, analytical approaches (Rittel and Webber, 1973). 'Soon the initial selection of questions in the design method was repositioned at another point in the framework, raising new questions and ideas considering the normative symbol of the material object' (Dezső, 2019). By repositioning the initial task (conceptual repositioning in design, (Buchanan, 1992) of problem-solving and place the situational nature into the focal point, the aim is to generate new knowledge and to explore Research through Design (RtD) for a shared understanding. The output of the novel method of the case study experiment is supported by argumentative and collaborative design practice, participatory observation, and also by self-reflective observation processes. Needless to say that the results of the aspirational theory of co-Ability is grounded on critical disability studies and posthumanism.

What –

Should design research involve projects that lead to artefacts? What defines the boundary of a design problem? The subject to be investigated remained in the case study with Luca Szabados and the development of prosthetics through digital technology. 'The focus on "real design" points toward design as performed in a designer's usual working situation—rather than in artificially restricted conditions, such as laboratory experiments' (Visser, 2006). To what extent do I have the right, as a designer, to see problems in cultural contexts I do not understand? Visser also 'emphasizes that an expression such as "design is not problem-solving" is an abbreviated form of the idea that "many design tasks constitute no problem-solving tasks for the designers in charge of these tasks" (Visser 2006). 'The development of prosthesis created with collaborative design practice should not target only methods of solving design problems, but also informal and social interactions in posthuman collection' [Dezső, 2019]. Simultaneously with the single-case study, I also added the teaching activities at MOME in collaboration with Csillagház Elementary School. I found it more than essential to include a great variety of fundamental evidence to understand disability studies and explore body-object relations in various student designs in order to see what constitutes evidence for a 'problem' and a 'solution'.

Where –

The research framework based on the situated design perspective (Agre, 1997; Lave and Wenger, 1991; Suchman, 1987; Winograd, 1996).

Winograd (1996) established his theory of the "situated" perspective in the nature of the design. The "situativity" adopts the complex sensitivity to the human context (Winograd, 1996). The research was characteristically a situated approach analysing the object-body interaction. It followed the object's transformation into a prosthetic as part of the "situated" action resulting in a tangible representation of co-ability theory (Dezső, 2019). The situated design framework for co-ability also invites further analysis of Schön's instances on "reflective practice," "reflection-in-action," and "knowing-in-action," which led to the exploration of additional research outside of the doctoral study in craft practices by considering co-ability in situated actions. The additional research was sponsored by the New National Excellence Program Scholarship (ÚNKP). It was presented at the Design Culture & Somaesthetics Conference Budapest hosted by MOME Doctoral School Design Culture Studies Doctoral Program and the Hungarian Forum of Somaesthetics.

When –

The timeframe of the study is limited to the doctoral period in compliance with Act CCIV on National Higher Education (NHEA) and Government Decree (GD) 387/2012 (XII.19.). The research started in 2016 autumn with the case study project. The design and theoretical research development followed for the next four years; the process offers a possibly never-ending undertaking. Understanding the problem is not a linear process as it continues to evolve until the end of research (Conklin, 2005). The present work represents the latest development of the design and the knowledge generated until 2021.

Who –

I consider four significant stakeholders in the study that define four different principles, framing a matrix of studies and represent fragmentations of novel and complex problems affecting the decision making activities (Conklin, 2005).

▸ First and foremost, disability brings social sciences and critical philosophy in posthumanism into the discussion, questioning complex phenomena of a normalised society that not only affect a marginalized population but every human being (Anspach, 1979; Barnes, 1996; Braidotti, 2016, 2013; Campbell, 2012; Goodley et al., 2014; Gustavsson, 2009; Liddiard, 2014; Mallett and Runswick-Cole, 2014; Meekosha and Shuttleworth, 2009; Ranisch and Sorgner, 2014; Shildrick, 2009; Verbrugge and Jette, 1994; Wolfe, 2009).

▸ Secondly, in pursuance of understanding a prosthetic as an object and as part of a human body, which also plays a role in human actions, the philosophy of object-oriented ontology, an embodiment that questions the borders of humanness, must be examined (A and Lucia, 2011; Brandt and Pope, 1997; Carruthers, 2007; Clark, 1989; Dartnall, 2004; Dourish, 2001, 1999; Doyle and Fraser, 2019; Gallagher, 2005; Haraway, 1987; Harman, 2018; Hayles, 1999; Mishkin et al., 1983; Reeve, 2012; Shildrick, 2015).

▸ In addition, contemporary technology in posthuman collection questions how we interact with technology and leads towards analysing time and questions the future (Agre,

1997; Bell et al., 2005; Doyle and Fraser, 2019; Finn, 2017; Forlano, 2018; Gregor et al., 2005; Hayles, 1999; Kamran and Abhishek, 2016; Mazé, 2007; McCullough, 1998; Tossebro et al., 2012).

▸Last but not least, the co-design case study presents the role of a designer not as an external expert but as a participant of the research with first-person perspectives (Cross, 1982; Hall et al., 2013; Höök et al., 2018; Kelley and Hartfield, 1996; Lawson, 2005; Sennett, 2008; Tomico and Wilde, 2016; Tomico Plasencia, O. et al., 2012; Wilde et al., 2017).

How –

Most data in this dissertation comes from empirical studies. The research conducted includes a description of the Research through Design (RtD) methodology (e.g., its experimental research based on a case study) (Buchanan, 2007; Gaver, 2012; Koskinen et al., 2012; Zimmerman et al., 2007). The study contains a careful theoretical inquiry on the relationship of design and prosthetics, leading to new knowledge. It also includes a detailed analysis to transform a practice project into research with the intention to explore research questions and demonstrate original research in this thesis that contributes to the knowledge of the design research field. I firmly claim that designing an artefact was not the main aim of this study. I conduct solid and significant research that produces artefact representing the thesis, in which the research both questions and presents a promising reflection on the issues studied in the doctoral dissertation.

Main questions in the study

The broad research agenda addresses several questions to cover such a complex topic. Questions range from the philosophical point of view of values through the functional achievements and interactions, all the way to the social and the aesthetic appearance, appropriate for the context.

- What are the ethical and political dimensions of design for disability?
- How does design help to improve the experience of being human, and not necessarily the user experience of a disabled person?
- For what kind of act or movement would a prosthesis be useful?
- How should a prosthesis or should not look like? Is it a usability question, or is it a matter of aesthetics?
- What kind of message is transmitted by a new kind of aesthetic in a prosthesis?
- How did the stable body image represented by Luca Szabados, and the embodied experience in self-recognition in the case study contribute to the research?
- What role can a designer play in a collaborative process of social intervention?
- How might the public's perception of designers be changed in order to present an image of a socially responsible designer?
- Is it necessary for design research to involve projects that lead to a market-ready artefact?
- What is the temporality of the body-object connection in prosthesis design?
- What are the spatial boundaries of body and object when it intervenes with technology?
- Why Luca Szabados does not like the idea of a prosthetic in the case study, and why do I, as a designer who intend to care and respect her, think that she needs one?
- How does the conceptual reflection of the world, as we already understand, is em bedded in the human body or the body of any entity?
- Is the futuristic transhuman nature of prosthetic developments connected to the 'bookish culture' that follows the old expectation of a biosimilar hand? If I don't fol low the past and recent tendencies of anatomical hand design, am I calling the prosthesis an artefact to help articulate unclear and unimagined possibilities of an emerging reality?
- If the prosthesis does not correspond with the anatomical reference of body parts, what form should it have? How should we proceed to form a prosthesis?
- What is another significant differentiation from a traditional prosthesis considered to be there?
- A small task of measuring the physical aspects of an elbow stump also posed the question: how feasible is it to consider a rigid object as a prosthetic attached to a non-rigid human body?
- How long should the prosthetic be attached to the human body?
- When a prosthesis is primarily a tool to interact with another object, how does this primary aspect vary between a prosthetic leg and a prosthetic hand or other pros thetic parts?
- What defines the boundary of a design problem?
- What is the relation between science and art?
- What does artistic research mean scientifically?
- Is Artistic research, design research, or scientific research being conducted in this dissertation? Can it fall in all three categories at the same time? If so, what does that mean in execution and what are the methodological guidelines, discussions in this matrix of research definitions?
- How is the structure of embodied knowledge in perceptual awareness related to body-centred human norms in society?
- How might a relationship between 'head' and 'hand' + 'materials' + 'tools' manifest itself in the context?
- What could happen if we consider that the cultural artefacts were produced by those no longer invested in maintaining human superiority in culture and politics?
- What are co-Ability's underlying principles, and how are they closely related to implicit knowledge?
- Why is a discursive prosthetic design so significant while connecting with the general viewer?
- How can discursive design research be presented to the viewer?
- How can the encounter with the audience be planned as best to view the project's argument instead of a result of terminal design production, instead of presenting a masterpiece of best prosthesis?
- Have these two views of human society or moral philosophy ever been separated from each other in time and space?

Theoretical framework & Definitions

Disciplinary distinctions applied in the research

The result of the research process gradually shaped the study with committed design research practice within the scope of combining different scientific endeavours and disability studies with artistic research. Indeed, in order to properly share theoretical advances, it is necessary to frame certain terminological matters to support the necessary critical discussion for further progress. In this case, the theoretical structure comes from different backgrounds, and as the scope of a given design field is relatively wide, the need to define the proper terminology increases. The line of definitions in this chapter mirrors the logical progression of thoughts, and there is no hierarchical taxonomy or alignment in it. First, the definition of design is specified as the starting point of intention. Design leads to the object, and it has to be understood how the prosthesis is considered here. By opening the situated discursive space of prosthesis design, attention is directed onto academic design research instead of terminal design production pivoting fundamentally to Research through Design. The subject of research requires clarification of critical disability study and posthuman study relating to the subject observed here. At the end of the logical observation, we arrive at outlining and defining the problem.

The meaning of Design in this text

‘What is being probed are characteristics that all design has in common, starting from the basis for it being called design’ (Willem, 1990).

‘Design is most often understood by the public as an artistic practice that produces dazzling lamps, furniture, and automobiles’ (Margolin and Margolin, 2002). Historically, design is easily identifiable on disciplinary terms based on the culture of materials like arts and crafts, architecture, jewellery, graphic design, or fashion, all commonly used in an educational and professional context as a defining indicator in material essentialism (Sandino, 2004). In this text, design is considered a part of the humanities and liberal arts, social and behavioural sciences, creative and applied arts. In academic stances of the humanities, design is also viewed as the ‘science of the artificial’ where the object and the phenomena are invented by humans (Simon, 1969).

For modernists, the two-folded discourse on ‘aesthetic’ and ‘pragmatics’ was the centrum of design. The ‘form follows function’ bilateral aspect defined the models of design. Since the beginning of the 2000s, there has been more consideration on the relation between the object and the user (Margolin, 2002). Herbert A. Simon's designated the meaning of design as the opposition to natural science by calling it a new "science of the artificial" in 1969. Since this definition, Paul Feyerabend, Donna Haraway, Stanley Aronowitz, and others have questioned the reality of nature. In this text, I challenge to view design by considering that the artificially made object become a part of the user, and these phenomena affect not only the user experience but mostly change the relation between the user and the environment both artificially and biologically, and – most interestingly for this text – socially as well. My intention is neither to analyse Jean Baudrillard's theory of exchange on nature’s presence in reality, nor is it to redefine the boundary discourse following Harraway’s cyborgs' culture. For further clarification, the term of prosthetic will be made clear below in the context of this paper. The focus is more on the transformative objectives of Social Design in a complex social systems of disability studies designing prosthesis prototypes for discussing the hidden or implicit nature of reality. Practically, the aim is to re-design the understanding of the social architecture within the process (Dorst, 2015).

Social design is discussed here in this paper, focused on Design for Social Innovation and Sustainability (DESIS), which is a strand of design practice with objectives and processes to lay the foundations of social change. Even though the contrast is blurry between the two definitions, the significant difference from Social Design (SD) is that it rather focuses on a closed community and the attention shifts to instigating a change for any community. Alteration is done by changing the patterns of ‘normal’ with fostering new perspectives. Focusing on the design of enabling ecosystems allows participants to adopt more meaningful roles within the design process, they become people with assets rather than people with problems, but this requires a paradigmatic shift in the way designers face the development process’ (Manzini, 2015; Munro, 2016).

Prosthesis

Prosthesis (Dezső, 2019). The definition of the prosthesis 'has a rich visual, political and material vocabulary in present time' such as 'prosthesis-as-artificial limb' or 'prosthesis-as-metaphor', prosthesis-as-aid of device, a part of the category in assistive device to support the action, an artificial body part that is 'integrated into the body's daily routines' (Adams et al., 2015; Dezső, 2019; Kurzman, 2001). 'Prosthesis simultaneously occupies the space of artificial limbs, metaphor, and discursive framework' (Kurzman, 2001).

Before presenting the mainly DIY-based prosthesis history and diving into the semiotic and hermeneutic aspect of prosthetic design, the denotative aspect, based on contemporary critical disability study and design culture study, should be questioned first.

- Considering bionormative body model from the point of view of a design process, does the form of a prosthesis need to be an artificial interpretation of biological limbs?
- Should it be a medical device, i.e., an aid?
- Do the spatial boundaries of body and object intervene with technology question the integration into-onto or even distant involvement with the body?
- What is the temporality of body-object connection in prosthesis design?

These concerns directed to the analysis of understanding prosthesis, resulting in considering a prosthetic design as a simple tool design for a person with disability to extend the power of doing by overcoming the limitation of the body just as for any tool already created in the history of design. Usually, when a tool is mentioned, a hand-held device comes to mind. Most of the tools demand an especially active skill that is acquired by participation engaging the imagination (McCullough, 1998).

As Ventura points out, 'the aesthetic attributes of a product (material, colour, and shape), combined with the interpretive dialogue between the designer and the user, brings forth a new understanding of the designed situation' (Ventura and Shvo, 2017). The situated dialogue is an important part of the presented prosthetic design. Also, considering a prosthesis with a direct object-body connection with a person is multiplied by knowing that the primary user is not the only user to be considered: primary users or end-users (the person with disability who becomes in direct contact with the prosthetic), secondary users (medical professionals, institutions, charitable bodies) and tertiary users (family members and other caregivers). The situated dialogue does not only happen between primary, secondary, or tertiary users and the designer, but more importantly, the social situation gets embedded in the object speciality inviting the general public into the cultural discussion. The discursive context with a person with a congenital disability in the case study presented later in this text locates concerns in the first place on both denotative needs of replacing a body part (that has never been there) and a connotative association on disability (which in Luca's case is self-questioned).

The term "Research through Design"

In my professional experience, time constraints did not permit me to experiment with design methodology or publish the works or discuss them in a professional environment. I made the decision to do academic design research to uncover hidden or not apparent trajectories from theoretical perspectives 'through' design practical experimentation. At the beginning of the doctoral study, understanding the difference between academic design research and design project research in means of validation and assessment was obscure.

Sir Christopher Frayling's distributed in 1993 three typologies of research in the design fields: Research for art and design, Research into art and design, and Research through art and design. In the multiplied interpretation, RtD is credited in several ways as an emerging paradigm (Gaver, 2012; Zimmerman et al., 2007) or as a research methodology (Findeli et al., 2008; Jonas, 2007). However, the history of RtD is still somewhat a brief one; therefore, it cannot be considered a well-defined research paradigm (Zimmerman and Forlizzi, 2014), and in this paper, it is frequently referred to as such.

The classification of design research based on Frayling typologies:

- Research FOR design (Artefact focused): it is highly relevant to the design since it is practice-oriented and driven toward the commercial market. It focuses on various parameters related to design output such as technology, ergonomics, and aesthetics with producing some form of tacit knowledge. It often builds upon previous knowl edge, and it is at times done without rigour and rarely considered scientifically ac ceptable for various reasons (Isley and Rider, 2018). The success of research is defined by the economics linked to the return of investment.
- Research INTO/ABOUT design (Research-focused): 'The research is carried out about design (i. e. about its objects, its processes, its actors and stakeholders, its meaning and significance for society, business, culture, etc.) by scientists (like an thropologists, archaeologists, historians, cognitive psychologists, management scientists, semioticists and many others) whose main goal is to contribute to the advancement of their own discipline' (Findeli et al., 2008). Design is the object of study.
- Research THROUGH design (RtD) (Artefact & Research focused): the origin of the terminology is borrowed from Herbert Read's "teaching through art". While it is relevant to the academic advancement of the design practice, it is also rigorous by producing original knowledge (Findeli et al., 2008). Design is the basis of scholarly research. The method can be studio work and research report, research diary, practical and tangible experience, and material research as well. It is also called "practice-based research", "practice research", "action research in design", "clinical research", or "project-grounded research"' (Findeli et al., 2008). As literature reviews indicate, there is still confusion regarding the adequacy of the Findelli taxonomy as RtD is the most controversial notion. Friedman criticises it for creating confusion with practice-based research concepts (Friedman, 2008). Nigel Cross argues that research for design can become a category of RtD in some conditions (Cross, 2007).

Even if RtD is currently not well-established and needs agreements on system and focus (Isley and Rider, 2018; Zimmerman et al., 2010), it covers the research undertaken in this study. 'Furthermore, it is through design that science exceeds being pure knowledge and participates in creating an effect' (Willem, 1990).

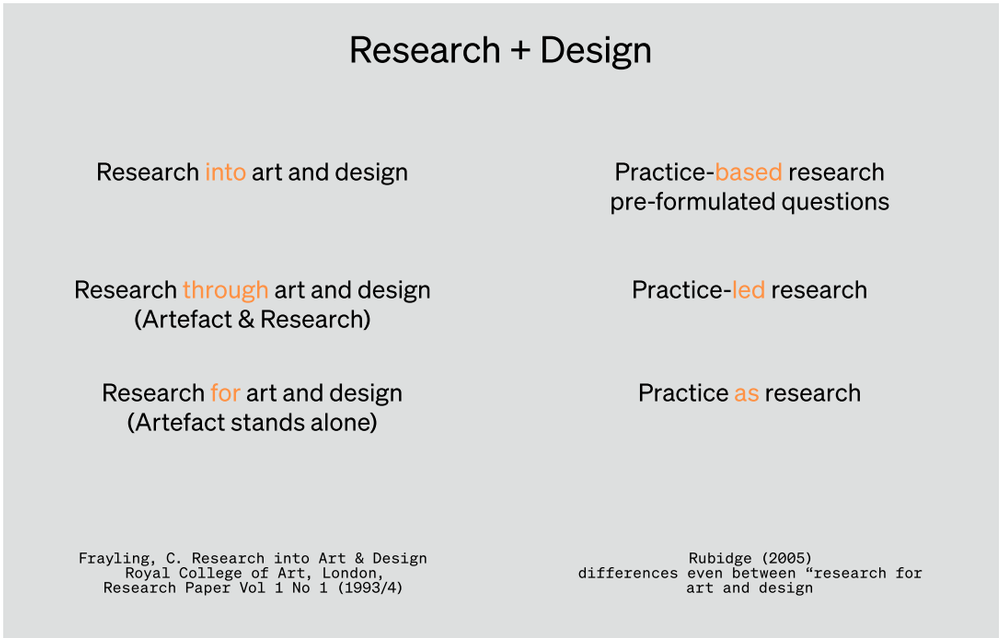


Figure 04: Design Research Classification Model – a synthesising diagram.

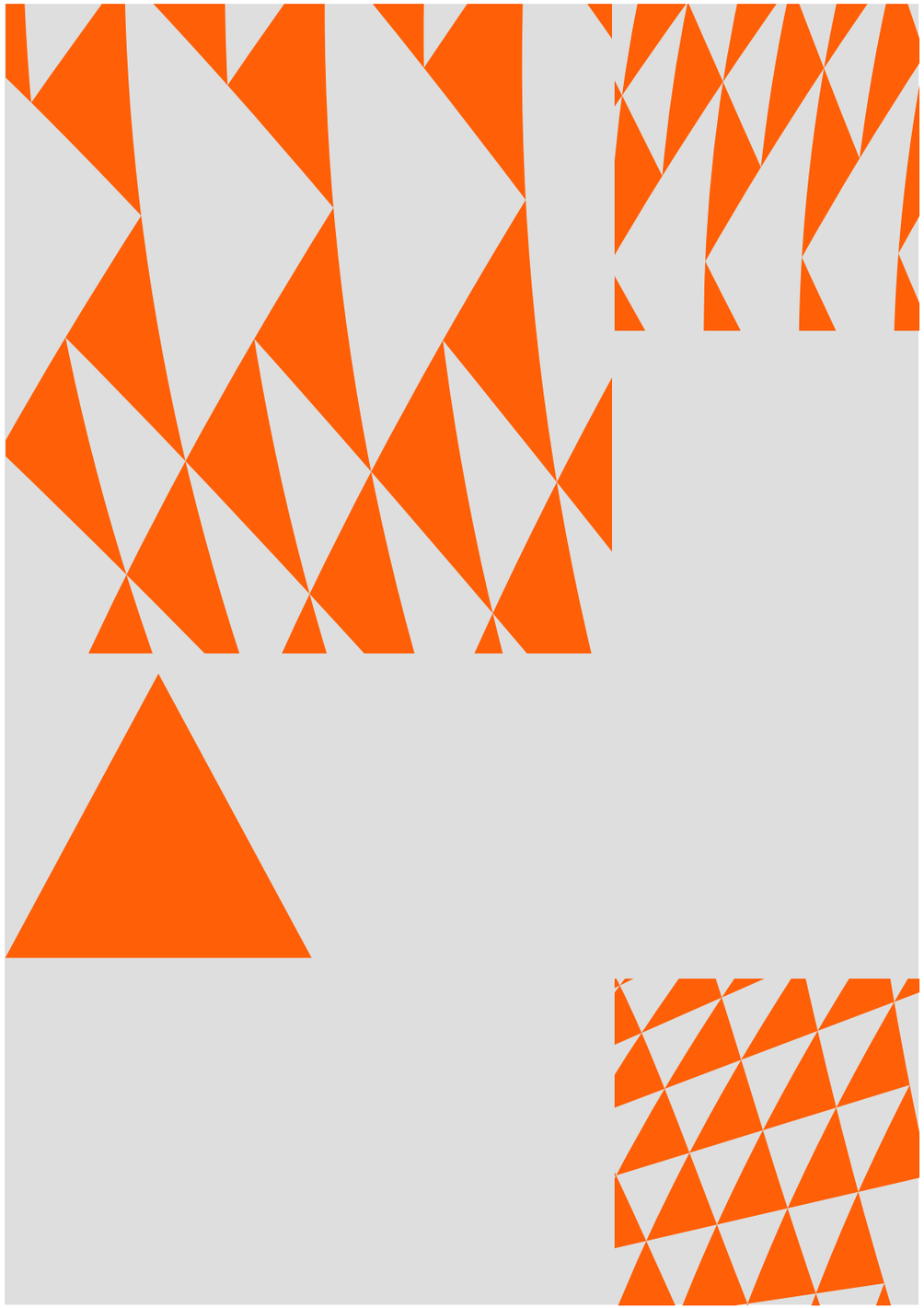
Critical Disability Studies and Posthuman Disability Studies

Addressing the controversial relation between humanity and disability contributes to a critical analysis of human-centeredness in contemporary design. The critical approach is not far from design fields, but to a certain extent, it is different from the perspective of disability studies due to the fact that it denounces the normative human concept.

Since we are living in a period when technology is increasingly integrated into our everyday life, the scope of discussion here needs to be extended to Posthuman Studies (Braidotti, 2016, 2013; Goodley et al., 2014) that invite disability studies to be part of a broader movement with ongoing debates on complex contemporary problems.

Problem-solving and co-design ‘design is not problem solving’ (Kelley and Hartfield, 1996). Hartfield, Kelley (1996) oppose design as a problem-solving process by defining it as a creative activity. Problem-solving is a creative effort, and these two aspects do not stay in opposition – on the contrary, they are in relation to each other. Allen Newell and Herbert A. Simon in the late 1950s dominated the complex phenomena of human learning and problem-solving, which was challenged in the early 1990s in cognitive psychology studies about how people solve unfamiliar problems. To solve a problem, it is necessary to understand what the problem is. The misleading part is the term ‘problem’, commonly understood as a ‘difficulty’ or ‘deficiency’, that ideally has to be solved at the end (Visser, 2006). This is precisely what Visser states when saying that ‘as long as the designer does not consider the design project as ‘finished,’ the ‘design problem’ is not yet ‘solved’ (Visser, 2006). Since design for people with disability manifests in social settings, ‘in real-world practice’ the ‘problems do not present themselves to the practitioner as givens’ (Schon, 1984) and can hardly be solved indefinitely. In the co-design method Conklin describes the never-ending jagged line of opportunity-driven problem-solving in the designer mental process (Conklin, 2005). A co-deigned process is not a terminal problem-solving design process; instead, it is a problem-seeking method where the design process brings up new situations to move forward. No wonder why ‘Sanders and Stappers therefore describe designers in co-design method as facilitators (Sanders and Stappers, 2008). The ‘problem settings’ of social design are not stable: they are mostly a continuously changing situation influenced by time and progress. They are aligned with co-design methods focussing on human aspects, where a person with a constantly evolving disability condition is part of the design process. It goes without saying that in this never-ending process, problem-seeking is more suitable if done by partial micro-solutions in prototypes reflecting and challenging new settings and new challenges. On a personal note, I must say that the creative challenge of finding a good problem that supports the progress of the research is always more important than finding a terminal answer to a single, pre-defined point.

I would differentiate the term of problem-seeking from how William M. Pena, and Steven A. Parshall described it with the five-step procedure for Architectural Programming, where programming is a problem-seeking method rather than a Design-focussed process (Pena and Parshall, 2012).



Chapter II.
Theoretical background

Introduction of scope of literatue review

With the primary design concern that genuinely focuses on inclusivity with a caring attitude, I was clearly not prepared to fully understand critical disability studies and their recent achievements. The Integral Theory (Wilber, 2005, 2000) is widely used to make scientific advances possible, integrating findings from various fields in order to arrive at comprehensive approaches aimed at explaining complex situations in an interpretative framework.

The genuine has to understand the needs of the person with a disability. Thanks to the valuable reflections Luca pointed out, it likewise made me reposition the initial selection of questions at another point in the framework. To proceed further with the research, I had to develop the research with the support of social science. At the same time, I had to be engaged in the form of implicit conceptual case-study work that distributed essential points to understand the literature. The two opposing approaches bent the workflow: the theoretical work processing such a large and continuously changing literature as disability studies, and the digital craft practice with a co-design case study. These two opposing practices, the theoretical and the experimental, formed the understanding of the literature reviewed and led to co-Ability's topical, procedural, pragmatic, and conceptual articulations. The study's objective raises a number of crucial issues that designers should be aware of at a time of significant challenges of anthropocentric societies.

The literature review presents the reflective symmetry in key elements between disability studies and design approaches, questions the validity of a homogenous human need, and reflects on how problem-solving can become a driving fuel for generating possibility. For this scope, first, I present the literature of critical disability studies and posthuman studies followed by relevant design strategies in the 20th century. In the end, I outline the similarities and differences between the two fields. I intend to present and follow the international canon of disability studies and, at the same time to introduce the relevant local studies as well as some personal experiences.

I want to highlight two main aspects in the literature: the implicit nature connected to stigmatising situations and the importance of a designer's personal role in the process of analysing design research methods that can take disability as the starting point for value formation.

I intend to investigate the most considered response, namely the 'design for care approach'. Then I challenge it, using critiques based on disability studies. In response to the critiques addressing the dominating power in non-disabled interests in the economy, I continue with a literature review on an analysis of Research through Design (RtD) that operates in reciprocal interaction within the fields of design, academic research, and disability.

Disability studied with the RtD method could uncover or formulate sets of alternative values present in everyday life experiences. Take the dichotomies of self/other, nature/technology, or human/machine, for instance. This is a process where the elaboration of disability culture – closely connected with design culture – affects and includes broad-ranging critique on non-disabled majority values. It uses the complex manner of the relational experience as the source of values and norms. Those values are significantly different from and even opposed to non-disabled majority values. Longmore argues that these values 'prize, not self-sufficiency but self-determination, not independence but interdependence, not functional separateness but personal connection, not physical autonomy but human community' (Longmore, 2003). I would name the works I present in this chapter as an 'archaeological' mapping process to support the reframing of the problems. Especially in design practice, understanding the patterns of habitual thoughts in history for technology-led or market-pulled stigmatising situations helps to develop a new value frame for generating ontological, epistemological, and methodological backgrounds of diverse findings.

Critical Disability Studies

Disability studies is a fast-growing and radically changing field that is difficult to summarise, yet I attempt to outline the main aspects related to the present study.

Addressing the ongoing controversy of disability issues, Longmore argues that disability is more of a social issue than a physical problem (Longmore, 2003). Longmore studies of history locate the problems in the defective social structures for disabled people instead of searching the root cause in biology. The radical reorientation in disability studies critically outlines the problem of unemployment and equal payment, unjust politics, prejudice, and oppression. He argues that traditional mainstream culture and politics tend to create flawed social structures by focusing on the human body's physical and functional pathology and by describing disability in medical terms. Mainstream culture should not be blamed for these misperceptions, though, as these notions were simply well-established ideas prevalent in the past. 'Critical disability studies scholars would add humanism's convenient relationship with medicalisation and psychologistic as colonizing tendencies of the body and psyche' (Goodley et al., 2014).

For example, as early as in the early 50s, sociologist Roger G. Barker discussed the social side of disability issues citing two opposing opinions: Francis Bacon stated that physical deformation is alienated with bad temper while Robert Burton declared that bodily imperfections increase the psychological sensibility of a person (Barker, 1948).

Since the equal rights movements of the '70s, the prevailing view of disability rose from the problem of an individual towards the problem of the wider society. Both in classical literature and in modern motion pictures, disability is exploited as a symbol of character and serve as a rhetorical effect with symbolic power. The hidden history of disability in media images and literature forge a social identity embedded in mainstream common sense (Baynton, 2004). 'Disability researchers state that the medical approach towards disability goes hand in hand with objectifying the body. Pathological judgement aims to change the person involved instead of changing the sociological context' (Dezső, 2019).

Disability studies based on the social model declare that the medical and pathology-based model renders the individual with disability incompetent and infantilised, leading to discrimination and stigmatisation. Stigma in the literature of social psychology is 'the situation of the individual who is disqualified from full social acceptance' and thus refers to the relationship in social situation deeply discrediting based on a stereotype (Goffman, 1963). The idea of the social model in modern disability history is rooted in the Fundamental Principles of Disability document first published in the mid-1970s (UPIAS 1976). The text influenced the

revolutionising role of disabled people in society and initiated the new radical activism refusing the medical pressure of correction or cure. The importance of the social model not only orient the focus on the cause of the problem in social issues instead of a person, but it also changes the condescending attitude and gives back the control of life to the person who lives with a disability.

By reviewing three principal books about disability, Longmore essentialises disability as a socially constructed identity that changes the view of a person. (Harlan Lane's When the Mind Hears: A History of the Deaf (1984), Peter Tyor and Leland Bell's Caring for the Retarded in America: A History (1984), and Hugh Gallagher's FDR's Splendid Deception (1985) (Longmore, 1987). "Disability is not a personal characteristic but is instead a gap between personal capability and environmental demand" (Verbrugge and Jette, 1994).

The newly gained social awareness-oriented disability from the pathological domain towards the political issues on rights movement affects decision-makers. The political view of disability characterised by altered attitudes from country to country is based on the conditions of the nations. I would like to outline two dominant characters of social disability domains based on locations.

'The Anglo-Saxon model communicates with a certain kind of activism, attacking the schemes of the masses. It supports subjective art by having critical and demonstrative attitudes. It strengthens the importance of belonging to a group – the unity of people with common determination' (Dezső, 2019). 'Associating to this model can be a strong motivation in emancipatory research focused on impediments to inclusion' (Levitt, 2017).

On the other hand, 'Most Nordic Disability research has been practical empirical policy-oriented research' (Gustavsson, 2009).

The 'Nordic model states that disability is in a proportional relation: if a disabled person cannot grab an object, it is the object that does not function well, not the other way round, which makes the socioeconomic organisation paralysing. This model does not demonise the society, its way of thinking is constructive, and suggests ameliorating' (Dezső, 2019).

The main argument of contemporary critical disability studies is not always about the fundamental notion of Rights around and about the Human, since not all of us are considered fully human in the common sense of being the former measure of all things in western culture. The 'posthuman condition introduces a qualitative shift in our thinking about what exactly is the basic unit of common reference for our species, our polity and our relationship to the other inhabitants of this planet' (Braidotti, 2013). 'The fast-changing field of disability studies is almost emblematic of the posthuman predicament' (Braidotti, 2013) and also gives an excellent opportunity to critically explore inspirational posthumanism. The post-human predicament is not a binary opposition to humanism; it is a non-dualistic understanding of nature-culture interaction explored by the scientific and technological advances of the present time. 'Many posthuman transformations are already occurring every day across the globe since our life is technologically mediated every day' (Dezső, 2019).

Critical disability studies in posthumanism share the deconstructive desire for the empire of the oppressive humanist 'Man'. This desire is shared with poststructuralists (like Foucault and Derrida), postcolonialists (Fanon and Shiva) and feminist philosophers (including Irigaray, Kristeva and Butler) (Goodley et al., 2014). At the same time, I agree with Braidotti's and Goodley's statements in saying that posthumanism is affirmative towards the positive elements of humanism by embracing the multiple opportunities in transversal subjectivity based on relations with human and non-human others freed from the empire of the humanist Man.

'Disability is but one cultural artifact that signifies the 'demise of humanism' (Braidotti, 2013, p. 151) precisely because disability demands nonnormative and anti-establishment ways of living life. To use the language of McRuer (2006), disability crips what it means to be a human being' (Goodley et al., 2014, McRuer and Bérubé 2006).

Figure 05: The two dominant models of understanding disability.

The affirmative perspectives on the posthuman subject change the ideal of a normative narrative in political and social identification institutionalised by many practices and by some design practices as well. In this study, I would like to emphasise the generative and productive potential of the posthuman predicament in design practice as well.

Local studies

I was first exposed to disability studies in Hungary in 2017 at the Fifth Hungarian Disability Studies Conference organised by the Institute for Disability and Social Participation (IDaSP), the Disability Studies Doctoral Workshop of ELTE Eötvös Loránd University, Faculty of Special Needs Education and the Disability Studies Section of the Hungarian Sociological Association (Bányai et al., 2019; Dr. Katona and Sándor, 2017). The conference's theme was 'Posthumanism and disability – what does it mean to be human in the 21st century?'. Personally, the conference was highly inspiring. Keynote speaker Prof. Margrit Shildrick discussed the questionable borders of the human body-technology connection and the embodiment of the prosthesis. The conference's goal was to make the theory more and more widely known by combining theory and practice, adopt an approach to disability science in science and everyday life, and thus promote a positive paradigm shift. The exposure to disability studies in Hungary was aligned with my recent artistic research workshop experience at the 57th Venice Biennale, where I was introduced to the work of Dan Goodley on Posthuman disability studies (Goodley et al., 2014; Jaakonaho and Junttila, 2017). Clearly, the experience made a significant impact on the course of the present research. Comprehensibly, the development of disability studies in Hungary is aligned with the international Critical Disability Studies representing high-quality theoretical, practical, and research results. At the same time, there is a critique of being a 'top-down process dominated by researchers and experts' (Kemeny et al., 2014).

In contrast, at the conference that followed in 2018, I have been invited to co-chair at the 6th Disability Studies Conference "DIVERSITY AS A SOCIAL VALUE?" of the Social innovations, Participatory Cooperation session together with the late Zsuzsanna Antal, bringing her extensive professional and personal experiences into the session moderation ("Sixth Disability Studies Conference 'DIVERSITY AS A SOCIAL VALUE?'" 2018).

I will not attempt to go over the entire ground of Hungarian disability studies literature or advance a distinctive interpretation of how diverse and developed it has become until today. Instead, I simply want to give an overview of a disputed, contrasting account of the local perspective for disabled people. 'Hungary was one of the first countries to ratify the UN Convention on the Rights of Persons with Disabilities (2007), the human rights' based approach is still very weak, due to the weakness of the civil organisations, deficiencies of political democracy, and the party politics dominated permanent transition of the Hungarian welfare state' (Kemeny et al., 2014).

Historically, Hungarian disability studies show that ever since the first institutions were opened in the 19th century and József Eötvös initiated the enactment of the law on our schooling system in 1868, there has always been a complicated and dismissive attitude towards special education. Initially, the ideas of social science and psychology were brought in by German influence through Hungarian scientists educated and working in highly successful educational systems and institutions of the Habsburg Monarchy (Kemeny et al., 2014). Historical forces informed scientific disciplines when the Habsburg Empire 'strategies of differentiation, inclusion and exclusion' imposed into the cultures and politics of disability in modern Hungarian culture (Buklijas and Lafferton, 2007). I limit the scope of this research to finding answers to a related question whether 'the more socially engaged and public-oriented Budapest intellectual and artistic milieu' affected responses to the common social and political situations differently (Buklijas and Lafferton, 2007). To be precise, my intention is not to collect and analyse Hungarian disability studies history and related studies, since there are more sophisticated studies available on the subject (Bánfalvy et al., 2006; Cserti-Szauer et al., 2020; Dr. Katona and Sándor, 2017; Dr Tóth, 1933; Gereben et al., 2018; Gordosné, 2000; Heiszer et al., 2014; Hernádi and Intézet, 2018; Könczei, 2017; Könczei et al., 2015; Könczei and Hernádi, 2015; Maróthy, 2009; Marton and Könczei, 2009; Sándor et al., 2018; Tausz and Varjú, 1991; TOTH, 2014). The doctoral research I am presenting in this text, therefore, also focuses on the 'benefits of academic life, which include a source of skilled employment within a position that is associated with arts practice, the presence of colleagues and potential collaborators, and working with students who bring with them fresh perspectives and a variety of experiences' (Bennett et al., 2010).

I would like to present the generative aspect as a driving force when critical disability studies, design and craft culture meet. The programs below also represent interconnected international and local studies. As a part of the doctoral research, a new educational curriculum was built at Moholy-Nagy University of Arts and Design object design department between 2017-2020. As such, reflecting on the local approaches, the important role of the unique Hungarian remarkable education history resonates with the programs developed with an integrative discipline research practice, which was most importantly determined by the specific user circle. Csillagház Primary School, operating in the 3rd district in Budapest, performs the education and teaching of children with multiple disabilities. The series of educational courses was launched in 2017 and evolved in a 'generative' manner from an initial smaller-scale idea responding flexibly to life-like effects in the following years, involving students and lecturers from the University of Applied Arts Vienna (UAAV). 'The word "generative" simply directs attention to a subset of art, a subset where potentially multiple results can be produced by using some kind of generating system' (Galanter, 2003).

'The stakes in the design process for people with disabilities are not only what the person can do with a new design object, but what they become altogether: the way they see themselves, the way they see their world, the way they connect with other entities, both human and non-human' (Winance, 2014).

The multi-stage educational program was implemented with the participation of M.A. students interpreting contemporary areas of design discourse through critical analysis of disability related to children with multiple disabilities.

In 2017 the initial semester-long 'Design for Care' course was inspired by Peter H. Jones' book (Jones, 2013), expanded by a 'Hack For Care' intensive, 5-day workshop. It was followed in 2018 by a 'co-Design knowledge-sharing exchange programme' between two design universities (MOME and UAAV), and finally, in 2020, the two universities organised the 'co-ability design practises matter and mind in disability' semester-long program rounded off with an exhibition (Figure 15). Each program had a different approach while they had many similar attributes, such as the direct collaboration between amazing colleagues and educational specialists from different institutions and departments (just to mention a few: Anita Takar, Bálint Veres PhD habil, Fanni Csernatony, Univ.-Prof. Dr. phil. Mag. art. Ruth Mateus-Berr, Mag. art. László Lukács), supportive collaboration between educational institutions (Csillagház Elementary School, University of Applied Arts Vienna, Moholy-Nagy University of Art and Design, MOME DigitalCraftlab), and financial support from various foundations (Hungarian National Art Institute-NKA, Austro-Hungarian Foundation for Action Budapest, Austrian Cultural Forum Budapest).

Indeed, our aim was to sensitise university students, so in each program, we collaborated with the special educators of Csillagház Elementary School to conduct a workshop for transferring practical experience (knowing-in-action), to learn from both children with severe impairments and their caregivers, to turn the experience into shared competence

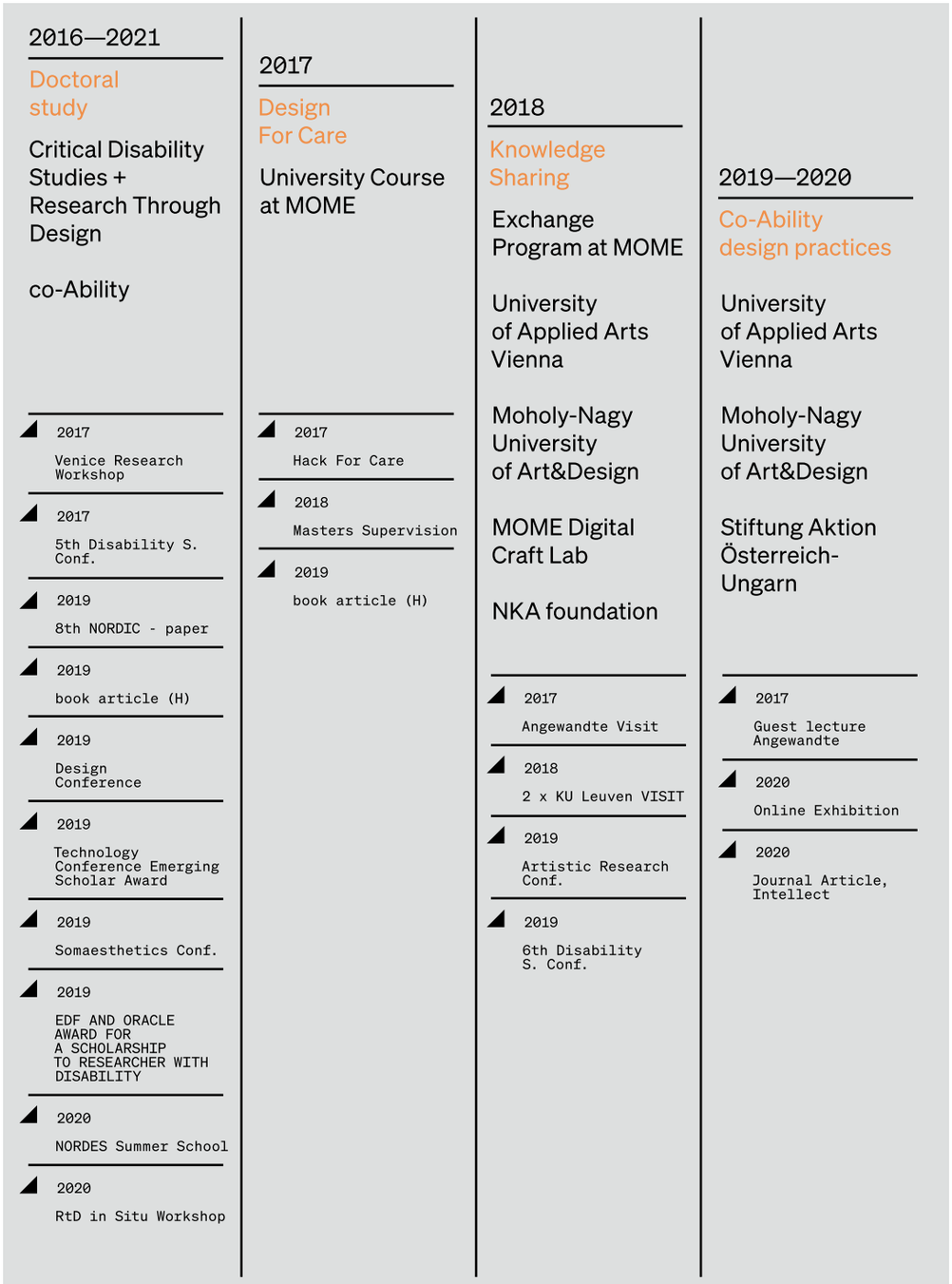


Figure 06: Multi-stage educational program at MOME.

of knowledge (knowledge-in-action), and to be able to apply specific professional challenges. We experienced how successfully the creative practice-research-teaching nexus negotiated in creating artistic output and that the accompanying academic discourse both inform and are informed by teaching (Bennett et al., 2010).

As a follow-up for each educational program, the documentation of the process of artistic research and publication of the results was well implemented on diverse platforms:

- Conference presentation
  28.-30. May 2018 TEACHING ARTISTIC RESEARCH, Curriculum and Pedagogy Conference
- Group presentation: R.Dezső, L. Lukács, R. Mateus-Berr, G. Urrutia Reyes, J. Rosoklija, Stefan Trimmel, (AUT, HUN, MKD, NIC) Co-designing for inclusion in international interdisciplinary teams
- Individual presentation: R. Dezső (H) Dissemination practice in university education with the aim of co-ability
- Article Publication
  2019 Full Paper presentation (En) at 8th biannual Nordic Design Research Society (Nordes) conference at Aalto University, Finland (https://archive.nordes.org/index.php/n13/article/view/463/434)
  2019 Book article (H), Study Summary at a Methodology paper for Disability Studies, Eötvös Loránd University. Title of the publication: Együtt oktatunk és kutatunk! Inkluzív megközelítés a felsőoktatásban. Editors: Szerkesztők: Katona Vanda PhD, Cserti-Szauer Csilla, Sándor Anikó, pp:153-161 | 4.2. Dezső-Dinnyés Renáta: Co-design – Oktatási programsorozat a gondoskodó tervezés jegyében. (http://www.eltereader.hu/kiadvanyok/katona-vanda-cserti-szauer-csilla-sandor-anikoszerk-egyutt-oktatunk-es-kutatunk/)
  2019 Conference proceedings (H), Study Summary at a Methodology paper for Disability Studies, Eötvös Loránd University. Title of the publication: Szabálytalan kontúrok. Fogyatékosságtudomány Magyarországon. Editors: Bányai – Fazekas – Sándor – Hernádi, pp: 154–166| 4.2. Dezső Renáta: A gondoskodó tervezés és gyakorlati reflexiók. ISBN:9789637155888(http://www.eltereader.hu/media/2019/11/Szabalytalan_konturok_2019.pdf)
  2020 Journal article (En) 'Co-designing for inclusion in international/ interdisciplinary teams', International Journal of Education Through Art, Band 16, Number 2, 1., S. 177-196 (20) Publisher: Intellect DOI: https://doi.org/10.1386/eta_00025_1
- Art exhibition
  2020 co-ABILITY Design Practises Matter and Mind in Disability
  'This exhibition represents the interdisciplinary work of students of two universities; design experiments between design and science with the focus on different abilities of an individual and cooperation among entities. The presented works do not solely show new objects or design products but interim results of research questions by design practice and design elements. The students that participated were in Bachelor or Master degree studies and derived from the departments of Art Sciences and Art Education, Social Design, Arts as Urban Innovation (DIE ANGEWANDTE) and Design and Art, Product Design (MOME).'
- Dissemination
  In the afterlife of the Design for Care university program, Csillagház applied for funding from Klebelsberg Intézményfenntartó Központ for small series production for selected students work. One of the students, Annabori Lányi developed her project

further for a master's degree project called 'PLAY bALL' with supervision by Renáta Dezső (https://diploma.mome.hu/2018/ma/lanyi-anna-borbala). In 2020, her diploma project won the Hungarian Academy of Arts Scholarship Special Competition Pro gram 2019 award.

The craftsmanship in the presented courses also encouraged emotional bonding between the works and students, the children from Csillagház, and all professional colleagues and specialists who participated. Crafting the product and its narrative can trigger associations and memories we carry with ourselves in the future. 'Thinking and feeling are contained within the process of making' (Sennett, 2008). The experi-ential benefit of crafting is something that meets the needs of children with multiple disabilities increased by the emotional attachment and satisfaction that can come from a relationship in the process. Craft and design culture offers a context for un derstanding the definition of these life experiences not only for people with disa bilities but for all of us. The value to explore disability creatively is to find the skills that can be strengthened through disabilities – eventually, the students are the future. As university students become a part of the future industry, they will significantly influence our daily life, and I hope they will bring their learning into their design cultures with awareness of crucial issues and keep the circle of collaboration in motion. The educational curriculum is clearly opposing recent decades' mass production culture where a gap between producer and consumer is distanced by the industry. Craft culture, also digital craft culture, is more often suited to the critical aspect of disability. I also worked at MOME Digital Craft Lab to explore the intersections of the digital and the analogue world to respond to contemporary challenges. The founder of the lab, Ákos Lipóczki's main aim was to achieve a contemporary, progressive, and market-compatible reinterpretation of craft areas, built on craft traditions, within project-based R&D activities using innovative technologies. As a researcher at the lab, I aimed at bringing technology and art together in my work in devices used in the areas of healthcare, therapy, and motion assistance.

Thanks to the main projects with MOME Digital Craft Lab, we obtained funding in 2018 from the National Cultural Foundation Hungary for initiating a professional connection with KU Leuven University. We intended to organise an exchange linked to the Culture and Disability program within the Faculty of Social Science at KU Leuven University in Brussels, integrating a new approach to applied arts between the par ticipating institutions. As a first step in the exchange program, we invited Patrick Devlieger, PhD, for a lecture presentation to integrate an up-to-date anthropological point of view for scientific development. The initial program developed in 2019 coincided with the Design Culture and Somaesthetics Conference in Budapest at MOME to invite Patrick Devlieger as a keynote speaker. Furthermore, in April 2019, four lecturers from MOME's Object maker program visited KU Leuven for the start-up Consortium Meeting Agenda Innovative Training Networks (ITN) for developing a joint educational program with cross-disability critical analysis to train individuals in the interdisciplinary field of disability studies, and to create changes in the welfare society, technology, ethics, and knowledge for impacting disability discourses. Later in June, the program developed further at the second consortium meeting, with other universities joining in. However, later in 2019, I had no chance to follow the ongoing program process as a doctoral researcher. I sincerely hope the valuable cross-national academic liaison between social sciences, humanities, and design studies will further combine the international disability research with the local re

search development in strengthening unused disability potential for future generations.

Finally, I would like to indicate here the locally conducted and internationally valued results of the study that summarise the knowledge from all academic programs and mostly the doctoral research with involvement of persons with disabilities in the innovation process was recognised by EDF (European Disability Forum) and ORACLE digital accessibility scholarship, awarding a researcher with disability. (http://www.edf-feph.org/newsroom/news/announcement-edf-and-oracle-award-scholarship-researcher-disability)

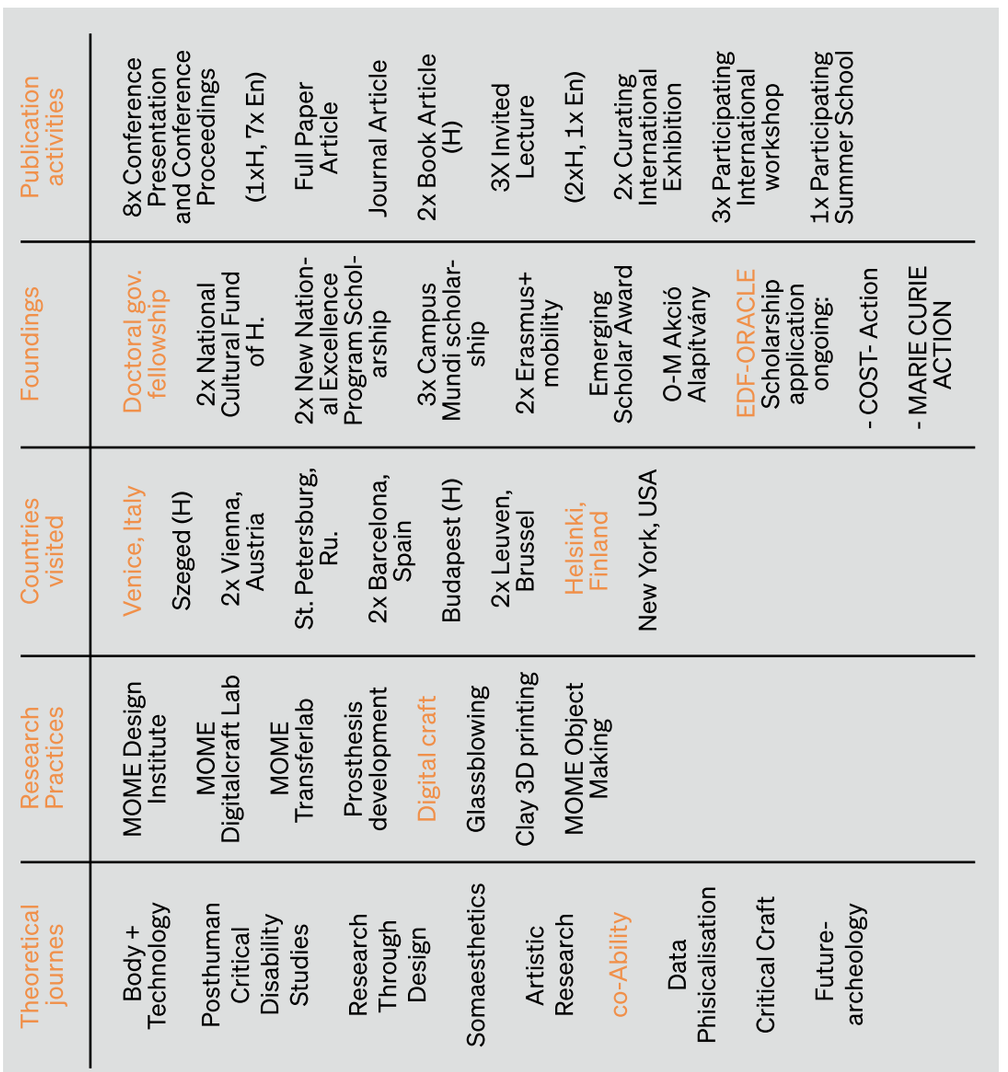


Figure 07: Network map of doctoral activity between 2016-2020.

Comparative and contrasting analisys

Design strategies critiques with disability study

When design meets disability, the starting point of a respectful response is the design FOR care approach, which can be a useful tool for developing essential design and design criteria that focus on improving the surroundings based on the needs of 'patients' perspectives. This dominant role of design is mainly based on creating better aid and environment for people living with cognitive, sensory, or physical disabilities. There are already many aspiring publications and cases 'offering advice and ideas on designing multi-sensory spaces and activities that meet the specific needs of the users' (Jakob et al., 2017), or for example, focusing on 'How to make a Sensory Room for people living with dementia' (kingston.ac.uk/sensoryroom). Both researched professional criteria and 'DIY' design guides are beneficial in care situations, participatory approaches, and co-design processes, also giving carers and care practitioners an opportunity to share their knowledge, concerns, ideas and build their confidence (Jakob et al., 2017). In the corresponding interactions between socio-political processes, medicine and science design appear. The initial scope of the study was to explore body-object interaction with prosthetic design adapting to body mechanics inspired by disability studies and developed with contemporary technology to fine-tune the aim to understand how design culture relates to disability. Chosen from the initial selection of questions in the mixed methods, a case study experiment with participatory observation and self-reflective observation design for care approach advanced towards a new novel design research-based framework.

There are two branches of important disability studies critique on industrial and commercial design categorised as technology-pushed or market-pulled strategies that have set my focus on a possible novel, contextual, and pulled approach.

Primarily, critiques focus on the current mass production in manufactured design creation because it homogenises the user's abilities, mainly when the development stems from a technological opportunity. Mass production is dominantly an economic decision enabling design to reach the largest audience possible. When it comes to design for the general public or most people's homes and communities, they weren't built with disability or ageing in mind (Prince et al., 2019).

'In the 20th century, the dualist account of rehabilitation engineering versus universal design is an appropriate starting point for further investigations' (Dezső, 2019).

To start with, the modern rehabilitation movement supported by governmental funds and guided by surgeons and engineers 'emerged to cater for the return of thousands of disabled veterans during World War II' (Brandt and Pope, 1997). The rehabilitation movement has grown a century later towards Assistive Technology, featuring the strategy known as 'technology push'. 'Efforts to improve prosthetics and orthotics resulted in a speciality that adopted scientific principles and engineering methodologies' (Tate and Pledger, 2003). The recent Assistive Technology industry covers a large number of mass products, systems and services in the medical and social domains with the aim of inclusion supporting functional needs (Plos et al., 2012). The competition among medical device manufacturers in the healthcare industry establishes segmentations based on monopolised policies linked to techno-centred know-how of a product, often on a global market scale. At the same time, medically specialised aiding products tend to be associated with stigmatising identity and segregation from the general population (Clarkson et al., 2003). Stigmatised social identity with deep and sometimes unconscious cultural prejudice tends to lower self-esteem.

To understand the stress caused by changes or by being considered different from the majority, I quote Don Norman's thoughts, an engineer who became one of the prominent leaders of cognitive psychology, and the expert who is trying to understand how the mind works and builds relations to environments and objects. In his historical book 'Design of Everyday Things', Norman implies that people (with or without disabilities) have the same attitude to failure related to everyday objects even if the fault lies in the device 'because everyone perceives the fault to be his or her own, nobody wants to admit to having trouble. This creates a conspiracy of silence, where people's feelings of guilt and helplessness are kept hidden and 'we tend to attribute our behaviour to the environment'. When we see others do it, we tend to attribute it to their personalities' (Norman, 2011) 'For designers, it is highly important to consider the appearance of an object in a rehabilitation situation because the social welfare model based on pathology is deliberately labelling' (Dezső, 2019). These medically specialised objects combined with novel technologies are mainly unaffordable without governmental help or charitable associations, and 'the clients are rarely seen as customers because they neither paid for their equipment nor had a major say in the choice of the equipment purchased' (Dezső, 2019). Serious consideration should be given to some particular concerns and critiques related to the physical application of money and power in an economy dominated by non-disabled interests. Take everyday design products such as architecture, objects, or even experiences: 'The ultimate cause of their marginalization is that people with disabilities are highly profitable. For that reason, they have been kept segregated in what is virtually a separate economy of disability. That economy is dominated by nondisabled interests: vendors of overpriced products and services; practitioners who drill disabled people in imitating the "able-bodied" and deaf people in mimicking the hearing; a nursing-home industry that reaps enormous revenues from incarcerating people with disabilities. Thus, concludes this analysis, millions of deaf and disabled people are held as permanent clients and patients. They are confined within a segregated economic and social system and to a socioeconomic condition of childlike dependency. Denied self-determination, they are schooled in social incompetency, and then their confinement to a socially invalid role is justified by that inadequacy. According to this assessment, disabled issues are fundamentally issues of money and power' (Longmore, 2003).

On the opposite side of the same medi-technical developments, when a global, market-pulled health industry is combined with a technology-pushed identity that implies association with the trans-humanist movements, 'four horsemen of the posthuman apocalypse: nanotechnology, biotechnology, information technology and cognitive science' (ibid, p. 59) appears. The tendency is already here today when a man/human is 'technologically mediated to an unprecedented order' (Braidotti 2013 p. 57) in the complexity of contemporary life. Although the transhumanist movement is highly inspiring for further study, I intended to keep the literature review focus aligned with the case study proceeded at the same time.

In recent years, there has been a significant number of highly-founded research on 'user-friendly' and affordable medical wearable devices projects in close collaboration with the industry developing advanced technologies, such as SocketSense - https://www.socketsense.eu/; SoftPro - https://softpro.eu/; Tolka Prol - https://tolka.eu/; Adams Hand - https://www.bionitlabs.com/; HelpingHAND - https://www.helpinghandproject.net/.

Design traditions

Rehabilitation Engineering Assistive Technology	Universal Design
‚technology push' strategy	'market pull' strategy
Medical research and development	Involves mass-production techniques with traditional design processes
Mainly in rehabilitation institutions	Needs of the widest possible audience in the mainstream
Unaffordable	Homogenizes the abilities of users Transforming the environment
It lacks the tools to address social complexity and emotional responses	
Transforming the body / Transhuman tendencies	

Figure 08: Design tradition in relation to disability.

In particular, I would like to highlight the Polish 'My Hand' research development project (https://myhand.io/en/) designing a '3D printed palm system that will allow one to perform selected activities. The basis for the design is the assumption that "I use prosthesis whenever I want, it helps me as a tool, but it is my choice whether to use it or not"'. The acre poetics of the 'My Hand' project is closer to the prosthetic development I intended to do in this research. However, there are differences between the presented research in this text and the 'My Hand' project. The design intention of doing parametric design and a system of a commercial product with a larger team and finding support was not the prospect of the present research. Doing doctoral research funded by a governmental scholarship as a single researcher allowed me the freedom to develop research led by the main questions from a particular single case study project and choose not to take the pressure of academic research trying to commercialise a terminal design product.

One of the valuable outputs of the research team is the collection documented in Wystawa / Exhibition @ Gdynia Design Days on '3D parametric prostheses which combine some of the features of what is available in the market today with the very unusual needs of their users, with the additional goal of being affordable' (Kabała et al., 2018).
The exhibition featured several contemporary prosthetic hands:

- ENABLE – initiated by Ivan Owen, a US puppeteer, who was inspired to develop a 3D printed prosthesis for South African carpenter Richard Van As. The project further developed into a distributed open-source prosthesis production, the e-NABLE community. One of the most popular models is the 'Phoenix Hand' (http://enablingthefuture.org/phoenix-hand/). The prosthesis hand called 'Cyborg Beast' was developed through user feedback (http://enablingthefuture.org/current-design-files/cyborg-beast-hand/)
- HACKberry is also an open-source 3D-printable bionic arm project, initially funded by exiii Inc., lately managed by Mission ARM Japan. The project is the winner of the 2015 Japan GOOD DESIGN gold award, and it was presented during Tokyo' designers' week in 2015.
- Open Bionics' Ada robotic hand by the Open Hand Project is being continued by Open Bionics. This is a 3D-printable, open-source project with assembly details for mounting a circuit board for a robotic prosthetic hand for amputees. Still, it openly offers the design to research platform for robotics or a test platform for prosthetics esearch.
- TINA is designed by the Polish jewellery designer Justyna Stasiewicz collaborating with the Open BioMedical non-profit Initiative. The future is the collaborative Bio medical development of low-cost and open-source, 3D-printable prostheses.
- Michelangelo and BeBionic upper-limb prosthetic solutions from OTTOBOCK. The bionic arm is controlled by nerve, and the company website advertises it to regain the user independence after amputation.

Prosthesis and custom-made cosmetic amputation supplements, offered by open-source,

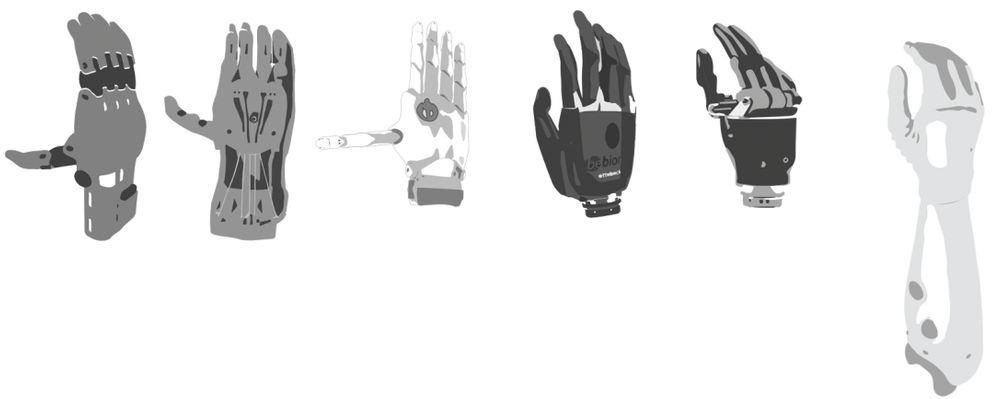


Figure 09: Phoenix Hand and Cyborg Beast by ENABLE; TINA biomedical hand; Michelangelo and BeBionic by OTTOBOCK; HelpingHAND.

non-profit organisations or medical device developing companies, are mainly constructed to have features that resemble an anatomical hand-worn long-term or to a body part used all day long, and concentrate on acquired disabilities more frequently than on congenital ones. The goal here is not to analyse these products, company efforts, user considerations, or even the market they occupy. The origin of the doctoral research steps back from the existing market and initiates an understanding of why user feedback expresses no desire for a prosthetic while the designer's initial idea was to create one.

Papanek in 1971 called the designer culture attention towards the 'genuine response to a real need' for those who "suffer design neglect" (Papanek, 1971). Questioning the social need of a classical prosthesis leads to the second large branch of design methods called 'Universal design' and 'Inclusive design'. These design aspects based on the social consideration of disability predominantly do not approach disability from the medical point of view. Instead, they attempt to adapt to the environment with the primary goal to satisfy the needs of the users. 'Universal design became a general design approach in which designers ensure

that their products and services meet the needs of the widest possible audience, irrespective of age or ability' (Story et al., 1998). 'Paradoxically, several studies on the field also report high rates of rejection and abandonment which can be caused by the lack of balance between people involved in creation (the designers) and end users (the nondesigners). The bottom line, however, is that both approaches have difficulties in incorporating the experiential knowledge of disabled users into their design process. The lack of contextual push calls for new types of research, such as cultural probes and generative tools which sketch out the user experience spectrum' (Stappers et al., 2009). 'The universal design is based on the principle of economies of scale, which involves mass-production techniques and traditional design processes characterised by the 'market pull' strategy' (Vanderheiden and Tobias, 2000). As an alternative opinion, the need to consider the extra cost of physical and personal assistance in stages of advancing disabilities is addressing a well-grounded design account of complex problems on economic interest in mass production for society. 'It makes good economic sense to invest in the design of cities and communities that are able to support people' (Prince et al., 2019). Margolin and Margolin identified that the alternatives of market pulled product design have 'not led to a new model of social practice' (Margolin and Margolin, 2002).

In response to the critiques mentioned, my focus is on non-commercialised design work, often taking the form of Research through Design (RtD), in which design practice is brought into potential situations for reasons to address possibilities and to discuss the implicit problems relay in the matter. To reflect on the research results allows the designer/researcher to articulate a range of 'topical, procedural, pragmatic, and conceptual insights' (Gaver, 2012). 'The design methods movement grew out of this need and generated the first cohort of design researchers focusing on the development of knowledge instead of artefacts for consumption' (Zimmerman et al., 2007).

It is an approach that does not emerge from a problem-solving perspective but one that tends to analyse theoretical concerns, engaging in dialogue with design practice and research methods. It is appropriate to address the desire to see a decrease in stigma and a heightened awareness that affect the reality of people living with a disability or, in other words, 'what people on the ground are feeling' (Prince et al., 2019). At the same time, I analyse the topic of posthuman/human binaries without a deconstructive desire to destabilise human rights. Posthuman disability studies are searching for productive alternatives in pragmatic practices and are affirmative rather than negative towards human ideologies (Goodley et al., 2014).

Leading design researchers Harold G. Nelson and Erik Stolterman discuss their concerns about designer responsibility in the complexity of the real world with powerful initial thoughts: 'Design is about creating the 'real' world around us. Real-life is complex, dynamic, and uncertain. Truth is difficult enough to know, even with the best science, but 'reality', the domain of human experience, can be overwhelmingly paralysing and beyond comprehension or understanding' (Nelson and Stolterman, 2003). Design can be defined as a considerable contemporary currency, in other words, as an 'Everyday Thing' that can bring frustration or satisfaction to its user while executing day-to-day tasks. Design connects multidisciplinary areas: it exists in architecture as well as in cybernetics; a design subject can be a traditional object or an intangible experience. When using the RtD method with embodied and situated (inter-)actions, research usually occurs at the interface between materiality and immateriality, culture and artefacts, and people and things. As Longmore captures it, the main goals of the fundamental features of disability studies agenda have a reciprocal relationship between academic understanding and the perspective of a person living with a disability. 'The disability perspective, the insights, experience, and expertise of people with disabilities, must inform research, producing new questions, generating new understandings. At the same time, academic researchers can help bring new rigour to the disability rights movement's analysis and activism' (Longmore, 2003). Design elements created through the RtD method not only serve as illustrative examples, but the related design theory is best considered as a form of annotation, explanation, and direction to features of 'ultimate particulars' (Gaver, 2012). There is a reciprocal interaction between design, academic research and dementia, a relationship with the design familiar with cultural values and material forms, humanities and sciences, technology and the aesthetics, reason, and emotions.

As Carroll and Kellogg have argued, the perspective of designed artefacts as a 'theory nexus' as RtD method embodies the object's implicit knowledge of the participants and compares it to scientific theories. These ideas range from the philosophical (what values should designs serve regarding disability?) through the functional (how should those values be achieved in interaction?), and the social (what will the people who use this be like?), to the aesthetic (what form and appearance are appropriate for the context?) (Carroll and Kellogg, 1989). I also agree that 'as design research becomes more involved in domains that have the potential to impact on our wellbeing, it would also benefit from such a structured approach to support for researchers' (Kettley et al., 2015).

Chapter III.

co-Ability Methodology

The chapter that follows presents and elaborates on an applied statement of the theoretical position of co-Ability, already discussed in the second chapter, and investigates the reasons why user-friendliness appears to come second behind the desire to help improve the experience of being human for the impaired.

To study the trajectories between Disability studies and Design culture perspectives, the application of practical design experimentation 'through' a single case study of prosthesis design with situated discursive co-design method is a reliable instrument. In the present chapter, I first talk about the RtD inquiry residing in the method and process of design practice. To understand the relation between the design process and the academic research, I discuss RtD to map out and develop a viewpoint of where this study stands in the realm of the research world. The novel knowledge-finding approach is not merely artisan as it attempts to relink academic theory and everyday real-life actions; it also wants to discover communicable scientific knowledge linked to the epistemology of the practice. It was hypothesised that digital craft combined with the unused disability potential specifically scrutinized through the argumentative RtD lens can lead to a better understanding of human-centred normative visions of our world.

To provide context to the design process, I present the single, in-depth prosthetic case study in which the research settled. The research introduces Luca Szabados as one of the key characters to settle the social situation and investigate her personal experiences within her real-life context. The process represents research into design innovation with situated variables and open-research questions allowing to change hypothesis predictions. In the prosthesis design process, the various entities analysed as key players are essential to the subject. A discursive prosthetic design is significant because it creates a connection with the general viewer by presenting the project's argument without emphasizing the result of a terminal design production as an absolute masterpiece. To articulate unclear and unimagined possibilities of an emerging reality, the prosthesis artefact does not follow past and recent tendencies of interpreting a corresponding anatomical body part. The form of a prosthesis does not need to be based on a bio-normative body model and does not need to be an artificial interpretation of a biological limb. Design research does not necessarily involve projects that lead to a market-ready artefact in which science and art meet and expand to the extent of design problems' boundaries. To recall Sennett's famous saying 'making is thinking' in the co-design process, I present the information gathered in the detection and production of data followed by the interpretation. The practice-oriented creative skills of digital craft analysed with rigorous science criticality address disability beyond identity politics and activism. The material conditions of digital craft are considered to be a process instead of a product. Consequently, it is understandable why design is more than an interface between a material object and its use. Another ground upon which this notion was popularly theorised was the manifestation of 'head' and 'hand' + 'materials' + 'tools' in the context, critically addressing the transversal form of non-synthetic understanding of the relational bond that connects us. As such, this text maps out and builds up a view of the co-Ability concept and formulates the understanding of co-Ability. It seeks to uncover the paradox in the dichotomous endeavours interplaying in body representations with the potential of leading substantial alteration in the overall perspective in which the problem is viewed (Bargar and Duncan, 1982). In connection to co-Ability 'I would suggest that the body representations are actually linked to the understanding of the bodily experiences of an individual, and it leads me to think it can be a description of the primary understanding of the world as well' (Dezső, 2019).

The public's perception of a socially responsible designer should not only be received when a designer plays an essential role in the process of social intervention. Concluding the chapter, I focus on another part of the framework: the question of interpretation and presentation of such research process analysing how art and science work together to inform the public on scientific information.

Research through design or craft?

In the first chapter, I clarified the term Research through Design. It was essential to understand the terminology in earlier chapters. Yet, at the same time, it still requires a more detailed examination to detect the position of this particular research and how it connects to the practice. Right from the beginning of the doctoral research, I found it essential to map out and pinpoint the approximate position of this research in the world of clashing opinions. This map supported the understanding of the novel methods applied in knowledge generation throughout the last five years. To best present, the process calls for clarification where design research stands here, so I have to define which actions are connected and how the methodologies are related. Before the doctoral study, my work was concentrated on product design or artistic projects. The two disciplines were separated by different processes, network connections, and artefacts, but with this study, the academic aspects are finally incorporated into the process.

As a designer doing academic research, I felt as if I was an artistic researcher sometimes questioning the scientific quality of the quest, and I was curious to find the correct answers. So, what is the relation between science and art? What does it mean to do artistic research? Is artistic research or design research happening here, or is it scientific research? Can it fall in all categories at the same time? If yes, what does that mean in terms of execution, and what are the methodological guidelines, discussions in this matrix of research definitions?

To begin, I would like to interpret how design practice presented in this text is related to artistic practice. On the one hand, design is an actual manifestation of tangible objects, products, or even a system, that is so to say in general, all 'things' that are artificially made. On the other hand, however, it is also a process or a method, which is closer to the meaning used in this chapter. In Design Research, the focus is on the latter meaning, on an approach of thinking and action. Rather than a retrospective and factual analysis of a final ideal object, the prosthesis prototype design is transformative in nature and provides context to this study.

How this text looks at design is not equal to the perspective of artistic or non-artistic aspects. Nevertheless, the predominant digital object making design activity refers to industrial design more than design engineering in additive manufacturing, considered a non-artistic form of design (Eder, 2012; Flurscheim, 2014; Julier, 2013; Tjalve, 1979).

The main future of design held here is the situated nature in our everyday life culture: 'design relentlessly intervenes into the quotidian world so that it becomes our world and we become in it' (Julier et al., 2019). The situated nature of design in our quotidian world is in reflective symmetry with how our moral and social values steer our behaviour on a daily basis. Combining the situated nature of design with a convivial situation of disability is the predominant perspective viewed here, with special emphasis on how it reforms everyday life culture. The conceding relation between society and market is often intricated in design history, recalling the Arts and Craft movement that mostly stood for the opposition of industrialised capitalism, as a 'critical stance towards the state of the market and capitalist product culture as such' (Julier et al., 2019). The criticality of craftmanship is also a part of digital craft movements or, in other words, 'maker movement' with 'technological developments that endow consumers with productive power' (Knott, 2013). The joint affiliation between craftmanship and technology is supported by a craftsman's 'right approach, skills and mindset' (Campbell, 2016). The manual skill-set and practised excellence combined with visual thinking of digital media can expand the perspectives of traditional making practices (McCullough, 1998). Based on these previews, the 'tight-knit cooperation between artists and craftsmen' (Julier et al., 2019) helps to understand the extent to which this academic design research is an artistic process. An artist's investigative skills may not be recognised as a direct application and manifestation of grounded research with subjectively informed interpretive analysis of cultural theory (Bennett et al., 2010). Still, interpretive and creative approaches of grounded research encompassed in scientific research are beneficial to qualitative inquiry, and mixed methods will positively impact the academy in the future.

So, after all, the question remains; What is research? The UNESCO defines research and experimental development (R&D) as follows: '[it]comprises creative and systematic work undertaken to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge' (UNESCO Institute for Statistics (UIS), 2008). This is an implication of not yet knowing. A theoretical or experimental work of investigation aiming at new/novel answers based on original concepts and hypotheses with an uncertain outcome. 'Science', 'design', 'disability', and 'technology' have a common aspect in being somewhat homogenous; therefore they trespass the boundaries of categories, and also represent variations in methods and paradigms in the shared common cultural everyday space. The knowledge generated by the present transdisciplinary research manifests the complex taxonomy of embodied perspectives, insights gained from material artefacts, communal experiences that can future-orientally reflect on the fundamental and theoretical aspect of science, and the usefulness of applicability design practitioners' and education community.

Prosthetic case study and repositioning the initial theory

To investigate through personal values and situated concerns, the research settled on a case study project for studying the instance of the designing process of prosthesis design. Articulation information embedded in the artefacts is part of the activity of the inquiry, including implicit and tacit knowledge-based data that are rarely verbally articulated. Prosthesis prototyping provides the possibility of creating a set of 'boundary objects' within design discussions which include latent perspectives carried out. In particular, the in-depth single case study was chosen because of personal interest in an individual with a contextual situation. The embedded part of the investigation, the design tool of prothesis, leads to theory building of co-Ability in social innovation.

The locus of the investigation built up by a single design case was initiated in 2016 at the 'MOME enable design tour' workshop, where I got introduced to Luca Szabados to create a prosthetic design as 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context' (Yin, 2003).

Luca's left lower arm is missing due to a congenital disability. She is a visual designer artist who primarily creates puppets for artistic performances. After being introduced to each other, we started to discuss what kind of prosthesis she needs and how she manages her daily routines. At this early exploratory stage of the case, the initial theories (she needs a prosthesis) and the initial questions (what does she really need?) were challenged by her representation of independence and creativity and her responses to my questions.

Right at this initial stage of her situation at the workshop, we clarified she does not need a prosthesis; moreover, she doesn't like to 'wear' one due to its weight. Also, she finds it weird and uncomfortable to move around with a prosthesis, often bumping into other objects. Her answers were surprisingly different from my anticipation: she questioned the design intention, inviting more questions to understand her personal needs and interests, redirecting the design process and the research trajectory altogether. The situated setting of the discussion was supportive on both sides: we had the genuine mutual intention to understand how the

two opposite intentions can be matched. The discussion was extended to explore further the necessary details and specifics on how she manages smaller daily two-handed tasks were covered. “Disabled people are often outstanding problem solvers because they simply have to be creative. Life for disabled people is a continuous series of challenges to be overcome” (Miller et al., 2004).

The particularity of the initial situation provided directions to further discussions and physical investigations; the framework of the doctoral research allowed to reposition the initial theories to elaborate it by novel critical/reflexive design discourses.

We established together that ‘both the aesthetic value for people around her and the somaesthetic experience in her freedom of movements were limited with classical prosthetics’ ‘she definitely wouldn’t need a prosthesis for her daily routine’ (Dezső, 2019).

Figure 10: Luca Szabados at her workshop. Photo by Andras Ladocsi. Photo by Andras Ladocsi.

Based on her reflections, we explored special occasions where she would appreciate a prosthesis. The work situation was the selected occasion in Luca’s routine when the performance could be improved by a designed aid. This is an exciting concept since all people prefer to enhance their work performance. We all prefer improved tools and environment to work with, not only for comfort but for higher performance and higher success. ‘By keeping an eye on the concept of inclusion, we focussed on improving the ability to work instead of pushing aesthetics to the fore. As a key situation for Luca, we defined the problems of using a cutter while working because this work exercise requires that she use two hands – when Luca is holding the cutter in her intact hand, the support she provides on a single point of the paper with her elbow stump is insufficient. If the surface to be cut is not supported properly, the cutting will be imprecise while the supporting elbow stump might be wounded too, which is more prone to injuries already’ (Dezső, 2019). Supporting the performance with the cutter is a short-term usage with a simple mechanical aspect. It does not require cybernetics or bioengineering as many prosthetic designs offer on the market with unaffordable price ranges for a simple customer.

A desktop 3D printed prosthetic tool can meet the surfaced requirements of producing a simple and affordable personalised prosthetic tool for improving work performance for Luca. By using the selected technology, some specifications also had to be considered, which I will describe in detail later in this chapter.

As part of the functional selection and technological details, one key feature of the design-led research question develops further. The design data, such as the prosthesis prototypes presented here lend themselves exceptionally well to narrative analysis. From this point of view, I was interested not only in what Luca said and did but in how she expressed herself to examine the forms and the functions of narratives. To match the necessary function, the prosthetic tool prototypes differed from an anatomical biosimilar prosthesis to a hand. The new aesthetic questioned the visual message transmitted by it, questioning how a prosthesis should look like. Longmore argues in several essays on disability as a matter of appearance as function in media images and screening stereotypes. The symbolic character of disability is dominant in media culture (Longmore, 1987).

A prosthesis functioning as a social symbol and a political emblem for oneself, the distinction between aesthetics and usability is blurred, or as Jauss discusses, ‘aesthetics just is the usability of an admittedly special kind’ (Jauss, 1982). ‘The design is a broad exploration of the problems of communicating information, ideas, and arguments through a new synthesis of words and images that is transforming the "bookish culture" of the past. An exploration of the problems of construction in which form and visual appearance must carry a deeper, more integrative argument that unites aspects of art, engineering and natural science, and the human sciences’ (Buchanan, 1992). Based on the earlier literature review of disability studies, a prosthesis that looks like an anatomical hand but is not able to function as an upper limb, the question arises: what kind of information does it communicate to the public and to the user? ‘Do I care more about social inclusion, or is it more important to sensitise the society? How should I eliminate the influence of stigma and divergence of the negative perceptions of difference (deviance) and their evocation of adverse responses (stigma)’ (Dezső, 2019)? The most valuable situation for Luca was her work situation. In (a) socio-cultural context (where), a disabled person is excluded from the commercial workflow with designed tools and environment; the(ir) inclusion is to adapt a tool to the environment instead of to adapt a person to the environment. In this case, the adaptive mechanism could be not for a disa-

Figure 11: Testing prosthesis prototypes with Luca. Photo by Andras Ladocsi.

Figure 12: Luca Szabados testing prosthesis prototypes. Photo by Andras Ladocsi.

bled person but the environment, ergo, so it is only reasonable to ask: Why should it look like a human body part? Should I form an anatomical hand, or should I transform the 'bookish culture of the past'? Strangely, the futuristic transhuman nature of the prosthetic developments are connected to the 'bookish culture' that follows the old expectation of an anatomical hand? If I do not follow the past and recent tendencies of anatomical hand design, am I calling the prosthesis an artefact to help articulate unclear and unimagined possibilities of an emerging reality (Bessant and Maher, 2009)?

'Based on Richard Buchanan's 'conceptual repositioning' theory, if I am changing the 'bookish culture' – in this case, the usual and expected shape of the lower arm prosthesis –, it will communicate a new status. Suppose the shape of the prosthesis does not follow the anatomy of the lower arm and the hand, and even differs from it significantly. In that case, it can emphasise the stigmatising expectations of the bystander. The important point in this context is that the expertise I was focusing on is a kind of knowledge that is practical and centred exclusively on Luca's experiences as a matter of principle. In this case, Luca's tacit knowledge guided the design, whereas I was in charge of transforming it to explicit wisdom so that it could be implemented. Her experience could also be called 'embodied knowledge' to emphasise the role of bodily abilities and capacities. Considering the pattern to change society's stigma, we can find a changing set of placements defined by shapes, actions, and thoughts. The shape of the prosthesis was defined by the actions for which it is being used, which, at the same time, produces a placement in representation. The boundary of this placement gave me a context or orientation to thinking, and the application generated a new perception. A person with a prosthesis – the materiality of the body – is invigorated in the given interaction. With further research, I analysed the nature of human rationality, subjectivity, and consciousness in the cross-disciplinary section of design culture and disability studies.' (Dezső, 2019).

In this research, I had no intention to make comparisons within other case studies to develop perhaps a causal theory based on measuring variables in the different settings of the various design projects. The goal was to know how Luca Szabados, in her everyday settings, interpreted 'her inside experience' and compare it with the literature study's 'outsider understanding' during the prosthetic design case study. The co-design process offered the ideal option for conducting in-depth analysis in one design's settings. In social science, addressing the meaningful character of social action using interpretive methods is appropriate. The historical debate between the positivist view of the natural sciences on valid knowledge contrasting it with the interpretive paradigm of social reality has been present since the nineteenth century. I do not intend to represent all critical points of the debate, but as an essential part of these opposing views, the tangible goes along with the objectivity. At the same time, self-reflectiveness leads to qualitative research (Travers, 2001). I would argue the tangible in craft experiences, and artistic research rarely goes along with objectivity. Instead, it is connected with a personal interpretation of an experience. When it is combined with the tangible experience of a person missing an upper limb, it can lead us to explore the implicit knowledge hidden behind social prejudices about abilities.

The rarity of this case study submerged in moving from the classical linear supplier/consumer model for research into design innovation with variables situated in this design research with open research questions avoiding hypothesis predictions. Luca's response to my initial idea and further works functioned as a 'Part of a 'critique from within' posed by a person with a disability with personal (implicit and explicit) knowledge of the situation, the prosthesis prototypes as 'object for discourse' were positioned as a basis for reflection in and upon the design. Ideas may be central, such 'objects that talk back' require the use, reflection, and action, through their very physical presence, materiality, and craft' (Mazé, 2007). The participants in the case study project were Luca Szabados (a highly creative independent artist with congenital disability) and me as a researcher/designer digital crafting the artefact with digital craft technology and the prosthetic prototypes guiding reflections through non-verbal modelling media. The experimental attitude of the following qualitative case study work provided space for understanding relationships between phenomena and theory. 'How we learn from the singular case is related to how the case is like and unlike other cases we know, mostly by comparison' (Stake, 2005).

Figure 13: Luca Szabados testing prothesis prototypes. Photo by Renáta Dezső.

"Making is thinking"

Processing data by forming and testing

If the prosthesis is not corresponding with the anatomical reference body parts, what form should it have? How should we proceed to form a prosthesis? What should other major differentiation from a traditional prosthesis be considered here? Differing from an accustomed prosthesis design also involves the intention to produce a low-cost and short-term use prosthesis tool, something that can be damaged in use without any stress and is easily reproducible if needed without high economic demand. 'Technology puts time central to 'Material practice', present 'return to things', 'temporal form', temporality of materials, use, and change, inflected by concepts such as becoming, making, and futurity' (Mazé, 2007). Furthermore, economically Luca's personal needs are very similar to any other person. All she wished for was affordable aid. Cost efficiency should be a part of the discussion when it comes to prosthetic development. We should consider the appropriate low-cost technology aligned with some bottom-up tendencies and contrast it with the recent highly funded bioengineering and cybernetics research developments in prosthetic design. In this respect, the discourse on cybernetic and organic attributed to the work of Donna Haraway's "Cyborg Manifesto" could deliver important arguments (Haraway, 1987). As I mentioned earlier, the philosophical question of aesthetics is an important consideration when it comes to prosthetic design, and low-cost fabrication technology offers new aesthetical appearances, too. Margolin and Margolin discussed that as the 'broader understanding of how to design for social need might be commissioned, supported, and implemented' when the 'population in need' is connected with 'design for development', the ideas are often borrowed from 'alternative technology movement, which has promoted low-cost technological solutions' (Margolin and Margolin, 2002). The digital craft process is based on isolating the minimal and most easily detectable parameters that can support to choose a specific action of material interception. In order to hold a flat-surfaced material completely steady, the number of fixing points must be increased at least to three, which quickly leads to an idea of a three-pod shaped form. Forming of such a shape was driven by the three primary parameters: functional aspect, time-based aspect, and the technology offered.

Design process step-by-step

1. The preliminary idea was an initiative with the best intention to design an ideal prosthetic supported by a university workshop for ideation. Similar to the recent tendencies of top-down problem formulation, the problem formulation focused on creating an ideal personalised prosthesis supported by digital technology.
2. Next, we discussed Luca's personal needs with her, which resulted in the conceptual repositioning of the initial task of problem-solving to the new objective of the research, considering the situativity in a case study aiming to generate new knowledge explored with research through design.
3. Closely listening to Luca's experiences and suggestions, the need for a general prosthetic was challenged as a 'bottom-up' initiative. In order to move forward, we defined together with a key function that can be supported by a prosthesis design I described earlier.
4. In order to start to develop a prototype and test its defined function, there was an important aspect to manage. I had to collect the exact stump measurements for prosthetic fitting, and it became apparent that three main options represented three different techniques for the initial ergonomic reasoning. The simplest possibility was an analogue process to measure the stump with a ruler or tape. After the measurements, the collected data could be inserted manually into the CAD modelling software. The second option was to use a traditional technique of plaster casting, which is a precise and feasible process without digital technology in place, but in order to enter the collected data in digital design, it is required that we reverse engineer and freeze the shape of the stump only in one position at the time. The third option was to use contemporary 3D scanning technology with direct digital data collection, which we did not have on the spot. In this case, the simplest and best option was the first one for various reasons. Ergonomically accurate measurement couldn't be precise and fixed in one body position since the elbow stump, like many other parts of the

human body, is a moving body part that changes shape and forms with movement. To comprehend the complexity of the measuring problem, Luca provided feedback right away. It was easy to select the most appropriate method to give a good estimate based on her feedbacks and my previous experience with 3D scanning and reverse engineering. At an early stage of the 3D scanning of the human body, the average micromovements challenged this accurate technology. 3D scanning geometric features of a static object with precision is much easier than a human breathing chest or a standing body that require spatial alignment in the calculation. Luca's elbow stump movements impose modifications that are much larger than a breathing chest. As a result, the alignment calculations should provide free space to be integrated into the object. To obtain comfort for Luca, the precision of the measurement was of secondary importance, so the classical tape measuring method was sufficient. The freedom of body movement in interaction with an object became more valuable in the design. This small task of measuring the physical aspects also questioned how feasible is it to consider a rigid object as a prosthetic attached to a non-rigid human body? The attachment between an object and a person questioned the idea of a fixed long-term connection. I wondered if the design should consider a short-term fastening connection instead of a permanent and lasting prosthesis integration. It also intrigued me; how long should the prosthetic be attached to the human body? Since the interaction occurs not only between the body and object (prosthesis) and in body-prosthesis-other object interactions. A prosthesis primarily is a tool to interact with another object. Therefore, the additional question of whether this primary aspect varies between a prosthetic leg and a prosthetic hand or other prosthetic parts remained.

5. The first meeting with Luca Szabados repositioned the initial theory and represented possible future comparative directions to fuel theoretical reflection on possible oppositions to this case study. The different demands for design in upper limb prosthetics and lower limb prosthetics need to be further explored. Also, another aspect affects the design process: Luca's condition is congenital. Her needs and reflections differ from a person with an acquired disability based on his/her self-concept and body recognition.

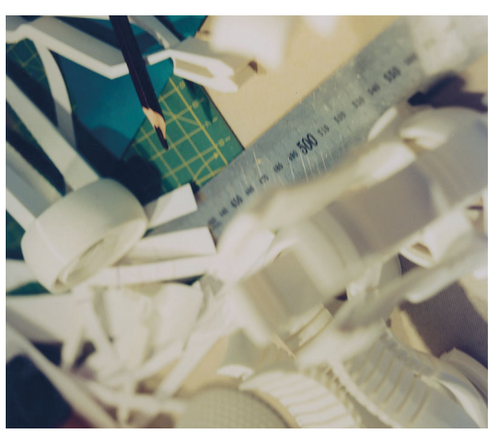


Figure 14: Luca Szabados at her workshop on the left, and prototypes to test on the right. Photo by András Ladocsi.

6. Main parameters of initial forming:

- The selected function is a mechanical aspect initially focusing on a single body motion, improving cutler use to hold a flat-surfaced material on three points. It opposes emulating the entire lower limb and hand functions to create complex body motions in terms of the limbs' external surroundings.
- Time-based aspects: short-term use. The design is enacted to the body only for the duration it is needed for cutting. The prosthesis should be easy to put on and off with one hand, or as later during the development we found out, it is even better not to fix the object on Luca or have an automatic fixing option like a click on/of the mechanical system of the hinge and joint. On a positive note, short-term usage does not require an ecosystem of hardware (equipment necessary for digital data input) to adapt the tool to the body, and the comfort of the surface material is less determinative, allowing a more straightforward object creation out of one material.

Figure 15: Short term usage supported by easy adaption to the upper limb stump. Photo by András Ladocsi.

- Technology-led aspects: computational workflow and structural efficiency
  - For cost efficiency, desktop 3D printing is used for prototype manufacturing.
  - The limitations of desktop 3D printing show as we worked with a rigid material called PLA; also, the size and detail limitations are significant compared to professional 3D printers.
  - The material is the media. Micromechanical structures can influence flexibility property on a rigid material property and also improve the body-object per formance. The leading art and technology inspirations in micromechanical structures are the works from Studio Bitonti–UNIQ orthopaedic and pros thetic products (http://studiobitonti.com/), Nervous System co-founders Jessica Rosenkrantz and Jesse Louis-Rosenberg (https://n-e-r-v-o-u-s.com/about_us.php) and Behnaz Farahi (http://behnazfarahi.com/) works. At the same time, the physical limitation of desktop technology does not allow micro-sized geometry and sophisticated material geometry. In light of such implications, it is still possible to alter the material's geometrical configuration with the strategic selection of geometry to showcase dynamic behaviour such as flexibility, thus improving the body-object performance

Figure 16: Various versions of the flexible side parts. Photo by Marcell Kazsik.

  - Assemblage: Desktop printing workflow offers the possibility to create an interlocking design, which we can use as an advantage in the shape of a pre-assembled bearing to support some of the body dynamics. Also, the elements cannot be larger than the size of an average 3D printer's bed size to conform to the needs of assembling the elements.
  - I follow a designer-based iterative development in computational design workflows, as opposed to a self-organisation process of Morphogenetic Design (Hensel et al., 2012). I propose a classical designer-based surface CAD modelling technique to support the development process of discursive situated design without using a parametric algorithm or generative design (Soddu, 1994).

Figure 17: A basic set of assembly. Photo by Marcell Kazsik.

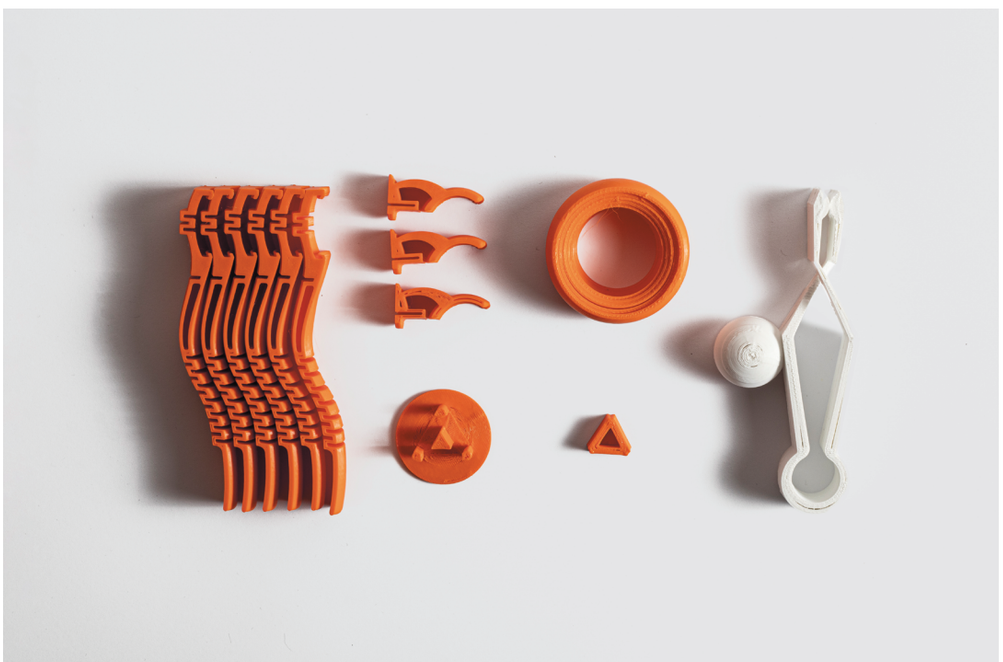


Figure 18: Set of assembly. Photo by Marcell Kazsik.

- Body-object interaction requires obtaining the best surface quality of the printed pieces. For this reason, the prints needed to have the least possible support material enacted to them. Due to the FDM printing technology, the printing process requires us to print a support structure that can be removed with physical effort leaving a rustic surface behind that can harm the human skin.

Figure 19: Set of the printed elements before assembly. Photo by Marcell Kazsik.

7. The primary phase of CAD modelling began after the first reflective discussion and the collection of real-world, measured data. The digital design method allowed to further analyse and visualise pre-collected real-world data. The initial digital models I first used for 3D production were testing the timing and calculating the possible assembly and other predictable physical elements. Aesthetic as a direct goal was not present at this stage.
8. The secondary phase of design development was based on digital data physicalising (Bader et al., 2018; Hogan et al., 2016; Jansen et al., 2015). The design 'activities focused on building physical manifestations of data, where some variable is mapped onto a physical artifact, are uniquely well-suited to scaffolding a process and exposing' for interaction to generate the next steps (Bhargava and D'Ignazio, 2017). This phase appeared and reappeared before and between the real-life testing with Luca. The process is similar to traditional crafting actions, which are rarely described in detail; the difference in digital crafting is the presentable data transfer within technological elements (computer, 3D printer machine) and humans. Some data code is readable only to the 3D printer, the artificial element, but not the human (python code to prepare to print). The code is textualised information generated by the 3D printer preparation software that helps the machine create physical objects from digital data.

In other words, the 3D image of a form created in the 3D modelling software is the visualisation of the pre-collected and designed digital data; the 3D printed forms are the physicalisation of the created data (Bader et al., 2018). Both the visual and physical representations of data are untestable and comprehensible to humans. But in the transferring process between the visual and physical, the information data are textualised and are altered into the 3D printer movements, and they are not understandable for an untrained eye. After each printing session, the printed parts need hand-crafted post-production, like detaching it from the printing plate, removing the support material from the surface, assembling elements etc. Sensing the physicalised material data through movements of the hand while moving the printed parts helps feedback simultaneously form the prosthesis's structure further. This activity supports two important sensual activities: the animated vision and the exploratory tool of touch (Ballard, 1991). Dana H. Ballard's animated vision paradigm research investigates ways in which fast, fluent, and adaptive responses can be supported by computationally less intense routines – routines that intertwine sensing acts and movements in the world. We see the information from the world during a movement and we change our action by considering that information. Based on A. Clark's description, we use touch to explore surfaces also as an action-involving cycle in which fragmentary perceptions guide further explorations (Clark, 1989). I would say I used the moving sensorial touch to understand not only the surface but the internal parameters of the material, such as morbidity, stiffness, relative weight, etc. Animated vision and animated touch are the tools for using the extended organs of physiology in the material world beyond our body.

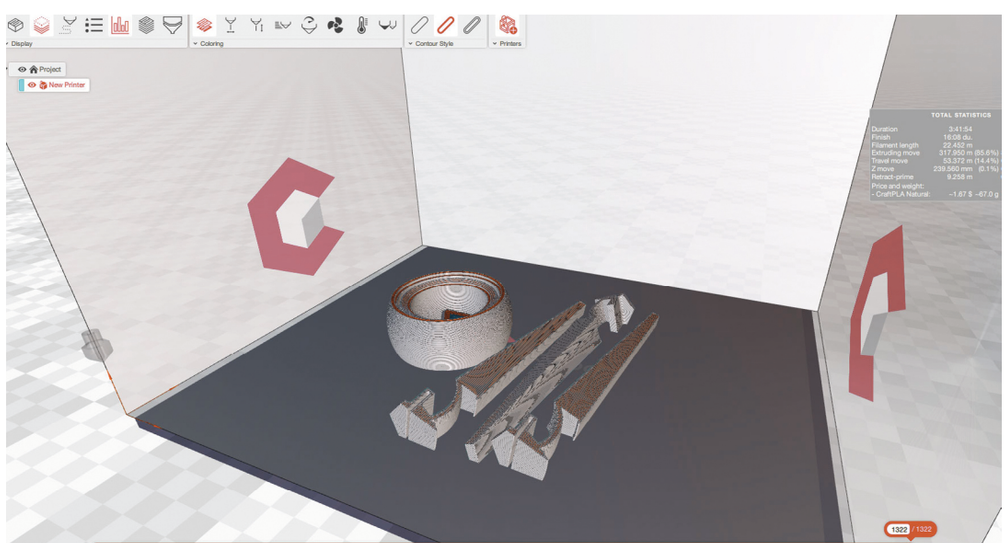


Figure 20: 3D printing setup without any supports

In this creative craft process, the designer can use the real-world prototype as its own best-structured information source (instead of a text-based information data source like in other sciences) and visit and revisit the real-world material scene as the idea of the envisioned design changes and develops. The process requires the

experienced nature of the movements in the material scene and involves subjective illusion into the motor-loop-specific perceptual adaptation. Paul Dourish (1999) explained the unfolding nature of situations when Heidegger argued the ontological structure of the world not given, not there to be found, discovered, or revealed, but arisen through interaction, through unfolding (Dourish, 1999). So, the prototypes hold a probe and reprobe material data structure; the information to improve the prosthesis prototypes are developing while action-oriented touch and vision generally extend the perception.

In other words, the two modalities of explorative touch and vision in craftworks are a parallel modality of the (body) image and (body) schema in self-recognition, that is, conscious and unconscious or 'online' and 'offline', implicit and explicit representations during a creations process (Carruthers, 2007). Body image and body schema will be discussed later in adaption to sensing the body.

The described process also begs for the question: can a single case study be considered as a qualitative research method with quantitative data collection and analysis in the digital crafting process? If the answer is yes, is this case study with co-design prototyping a mixed method that combines qualitative research, grounded theory, and meaningful variation in quantitative secondary data presented in the artefacts?

9. When the testable prototype became ready for use, we once again met Luca for usability testing. The initial tests were not in a real-world environment, but Luca received one prototype for more extended independent real-world testing at her workshop. Several prototypes were tested at the meeting to see the proportional aspect, fragility (some had cracked). I valued her short-term feedback and returned to change the design. The reflective discussions' main and returning physical characteristics focused on her comfort in moving around with the object. She generally needed the prosthetic tool for 5-30-minute-long periods, so I genuinely was interested to see if there is a need to soften the surfaces of this rigid PLA plastic. Another section of interest in function was how the prosthetic could be fixed on her elbow stump or arm, and generally, the process of attaching it onto it. Especially the take-on take-off processes were significant: they were not supposed to be too complicated since it could have reduced the satisfaction of use, which might have resulted in Luca not using it at all. Later in the process, she suggested not to fix the prosthetic at all to her stump and have an option of fast docking, which was an interesting proposal considering a traditional prosthesis. During the observation of the ordinary use of physical and material things in focus, our attention was drawn to details within embodied action, situated interaction, and social practices.

Figure 21: Luca Szabados testing the prototypes. Photo by András Ladocsi.

Evidence data in artefacts

The research argument is supported by the evidence provided by the data of prosthesis prototypes. This evidence is generated through the application of the design research methods in the social context of disability studies in the form of the production of material objects, which is given to establish the point in question. Data (plural, singular ‘datum’) of the material object become information when produced, tested, and interpreted in the social contexts of the case study.

Various methods will generate multiple types of artefacts: for example, an artistic method may yield personal interpretations or expressions; research for design with market-focused development would represent a market-ready product; research about design and traditions would result in a representation in objects of material culture or practice. ‘Different types of research method can provide different kinds of evidence which, when seen as a whole, can provide a ‘rich picture’ of the issue being investigated’ (Gray and Malins, 2004).

In this section, I present the two analytic themes of the prototypes reflecting on a selected function to provide support for Luca and make the limitations my choice of data imposed below explicit. To define two restricted data sets in the creation process, I focused on supporting a flat surface with ‘tripod support’ and the imitation of the ‘grasp’ with attachable modular grip elements. I describe the roadmap of the development and reason for the details of technical feasibility. In order to do so, I employ several methods like illustrative drawings from the 3D models in addition to photographs of the 3D printed objects themselves. Finally, I present the evidence after it has undergone Luca’s testing.

Figure 22: 3D printed artefact in use. Photo by András Ladocsi.

Figure 23: 3D printed prototype, photo by Marcell Kazsik

Tripod support: the central theme for the prototypes

Using a cutler is a typical task for Luca, and in order to improve her working quality, stable support of a flat surface on a table would serve her well. The function is not a tripod grasps describing a grip on a pencil, but tripod support of a flat surface such as a paper on a table which can be moved by the cutler pressure.

One of Luca's main movements with her elbow stump is putting pressure against different surfaces, even towards the side of her chest when she needs to hold an object. The force of the elbow stump is central to her lower arm. This direction has led the prototypes' shape to have a centre line and all elements symmetrical.

The tripod support works as a tool that is used for seconds or minutes while cutting. Adapting it to the body is not only temporary but it also extends Luca's lower arm only when it is in function/use. When the cutler is used, Luca's visual focus is on the surface to cut, and she adapts the place of the tripod support by her other hand without looking at it. For this reason, I added a tangible outer surface to the central element.

As for the critical technical aspects to design, it was important to build the 3D printed parts of the tripod support with interlocking elements. The probe and reprobe method were executed faster when the design without external material for assembly was tried. In further development it had a leading role in the design and also in thepersonal printing process. No use of glue or screw to fix the parts could have been obtained with proper interlocking shapes and gaps for movements. The central part of the design was ideated from one-ball rotational bearings as the movable components were printed in one. The mathematics required to determine element sizes according to the resolution of the desktop 3D printer and the correct gaps between components were critical. We can say that the three legs and the upper closing smooth surface naturally serve as the interlocking elements that build the whole object together. There are three size variations that can adapt to the height of a table Luca is using in her workshop, since she has a standing table and a sitting table as you can see on figure 26.

Figure 24: Size testing. Photo by Renáta Dezső.

Figure 25: Tripod support movement by Luca. Photo by Renáta Dezső.

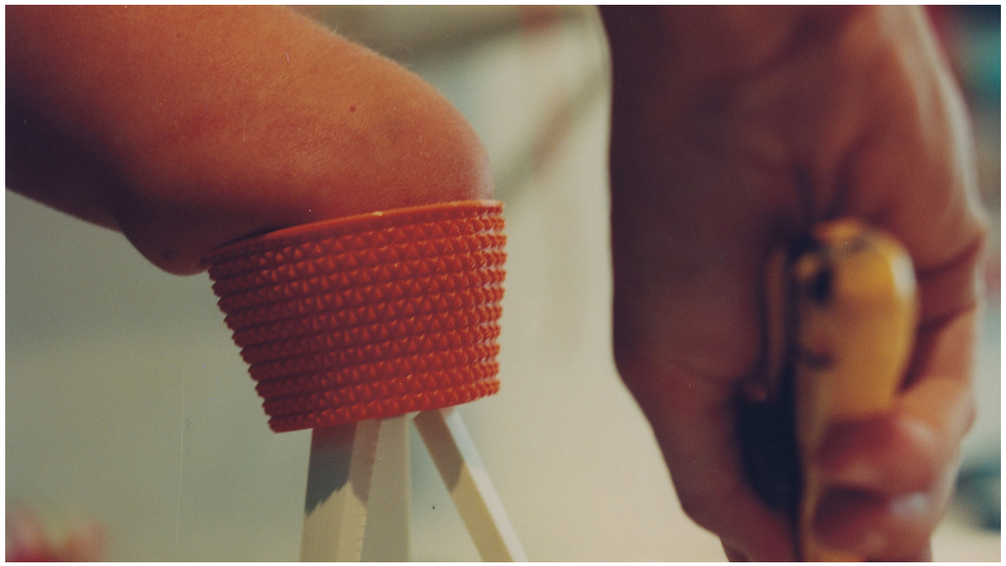


Figure 26: Flexible connection with the elbow stump. Photo by András Ladocsi.

Figure 27: Luca Szabados testing the prototypes. Photo by András Ladocsi.

Figure 29: Leg development series. Photo by Marcell Kazsik

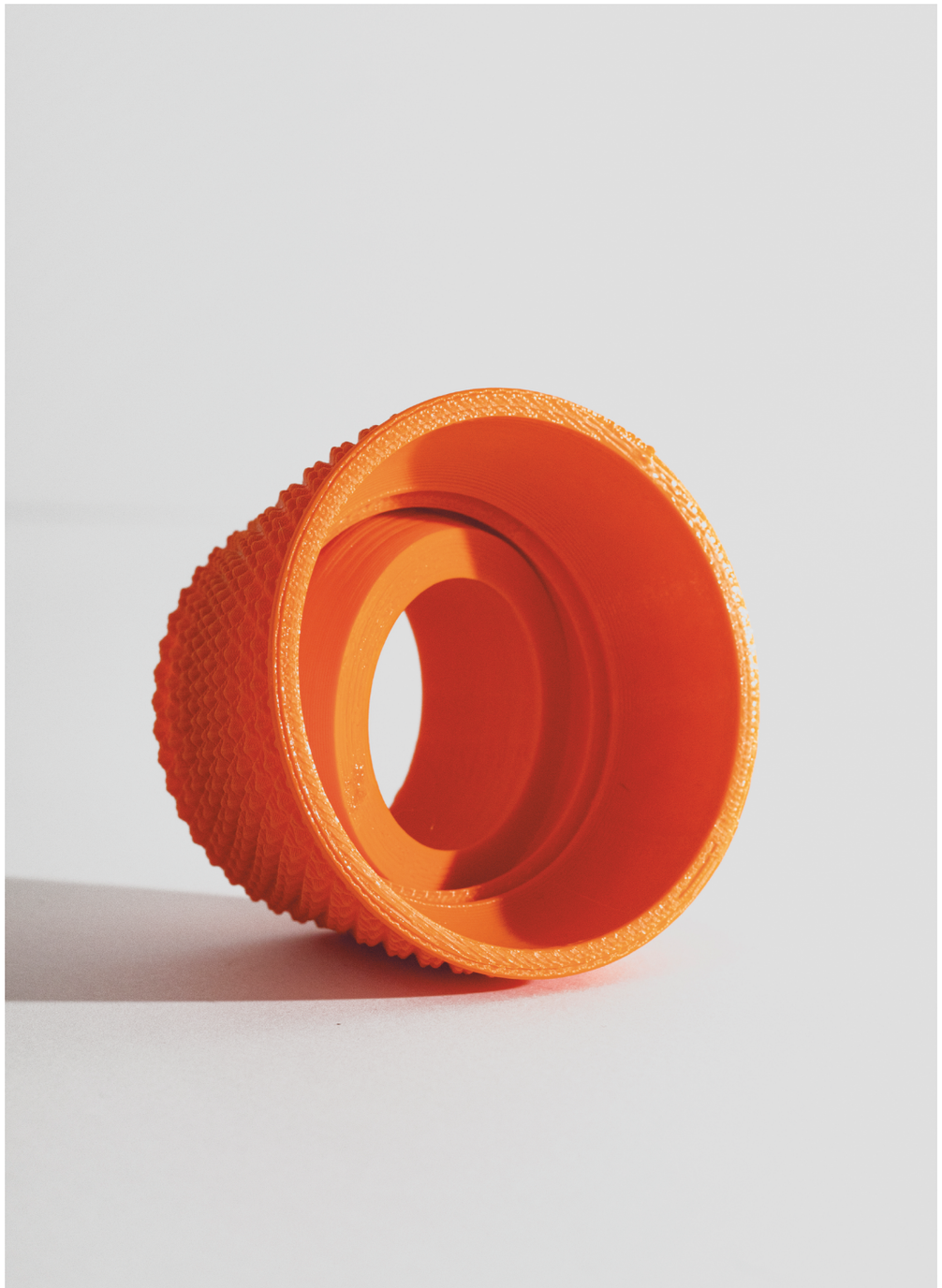


Figure 30: 3D printed bearing gear with the tangible exterior. Photo by Marcell Kazsik.

Figure 31: Try and Error versions. Photo by Marcell Kazsik.

Figure 32: Various versions of the prototype. Photo by Renáta Dezső.

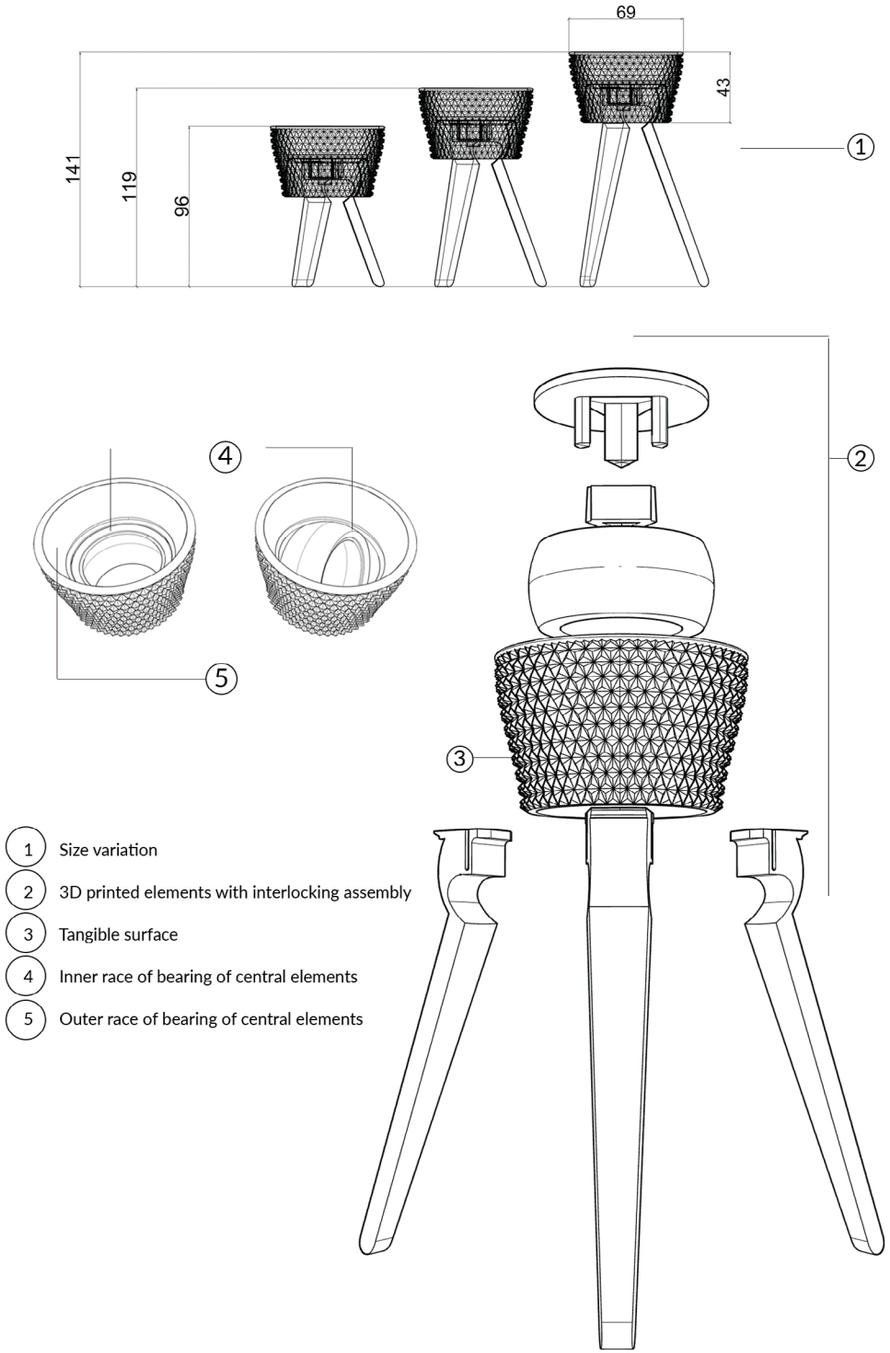


Figure 33: Exploded view and assembly with the centre element with tangible outside surface and bearing feature with the necessary gap to be able to move but printed as one piece.

Figure 34: Luca Szabados cutler use with the prototype. Photo by András Ladocsi.

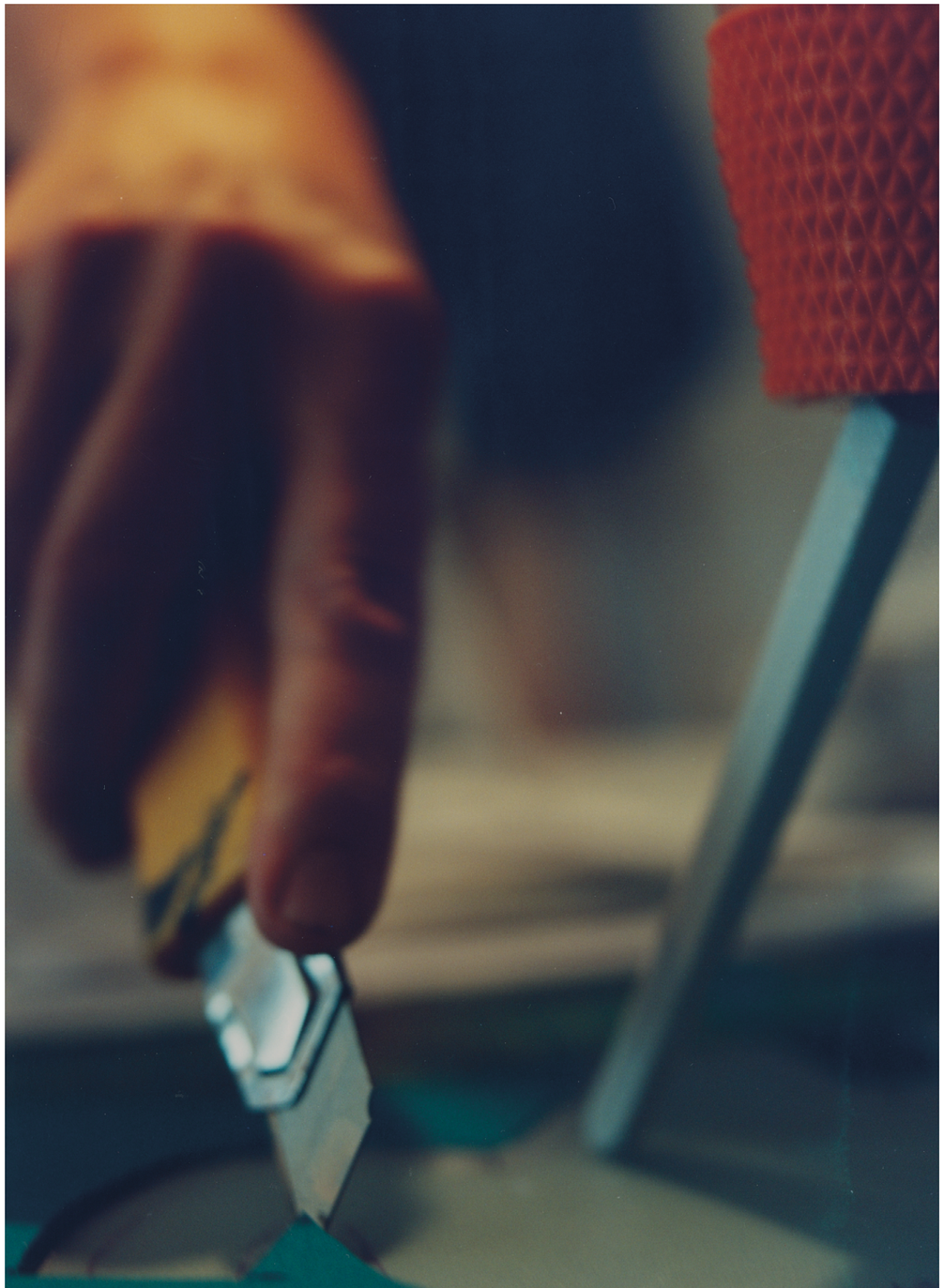


Figure 35: Hand and prosthesis side by side. Photo by András Ladocsi.

Modular grip:

We continuously returned to the question of what else could be useful for Luca as a prosthetic; what are the situations where an artificial tool can be useful for her? There are several small situations, mainly activities that relate to preparing a meal or social involvement such as card games or beauty routines such as nail colouring or hair drying.

The secondary sets of constructing elements support the structure of prosthetic development. The structure contains three elements:

- A side piece is an element that is connected with the elbow stump. It helps to fix the prosthetic. It was necessary to have an easy fitting that can be managed on the spot – An adaptive mechanism towards the human body.
- A modular element to connect with a particular object or a surface. This element adapts to the required function and object – A modular adaptive mechanism towards the outer world.
- A central bearing piece is an element in-between the other two to support the assembly, provide flexibility, and constitute possible modular variations – A fixed element in size and form.

All are made for short-term use, where a prosthetic tool could be used for 1-30 minutes. To adapt for independent application of a prosthetic tool to Luca's elbow stump, I developed a flexible side piece that is easy to attach or detach to the outer face of the central bearing element. The ideation originates from the double Gaussian curvature laser cutting wood technique. The designed set of side piece elements allowed Luca to quickly and simply fix the prosthetic to her elbow stump and quickly release it in seconds. Also, the flexibility of the features following Luca's arm movements without limiting discomfort was supported by the shape of the sidepieces bending in one and two directions while lightly increasing in stiffness and load capacity. To put it on was practically a second long movement, while at the same time, it allowed Luca to handle lightweight objects with the prosthetic tool on. The technical challenge in the side elements was to design a rigid fabric into a flexible one. I had not used parametric programming but classical Rhinoceros 3D modelling. The CAD modelling and the 3D printing workflow allowed me to improve as I learned from failed attempts to find a three-dimensional solution based on a variety of hinges. It was crucial to understanding some generic analytic themes of the prosthetic prototypes, such as the representation of the engineering aspect of the design, which does not comprehend the complexity of uncertainties and ambiguities of social context. The exploration of the diversity of a social phenomenon resulted in a large number of prototypes with various levels of execution.

In this case, the other side of the central bearing part is designed for possible modular assembly for further development and for adaptive pieces in the future. The logic of the design follows the same structure as the tripod support design logic. Once they are locked in place, the interlocking tree part forms a bearing bed for modular adaption. The external modular elements had a single ball as rolling elements locked into the bearing bed.

Once the main part of the modular grasp prosthetic tool is assembled, any newly developed function is easily attachable and detachable into the main centre piece. Two versions are presented below for the flat grip function. One is a general autoclip forceps; the second is a large mouth clip for card games specially made for Luca's request.

The roadmap of the details in the artefact suggests that I highly relied on my previous design experience in ideation and in the development of critical elements; meanwhile, I needed to be open-minded and critical about the prototypes, recognizing that whilst there were corroborating forms of solutions, there were ill-fitting models even for 3D printing and

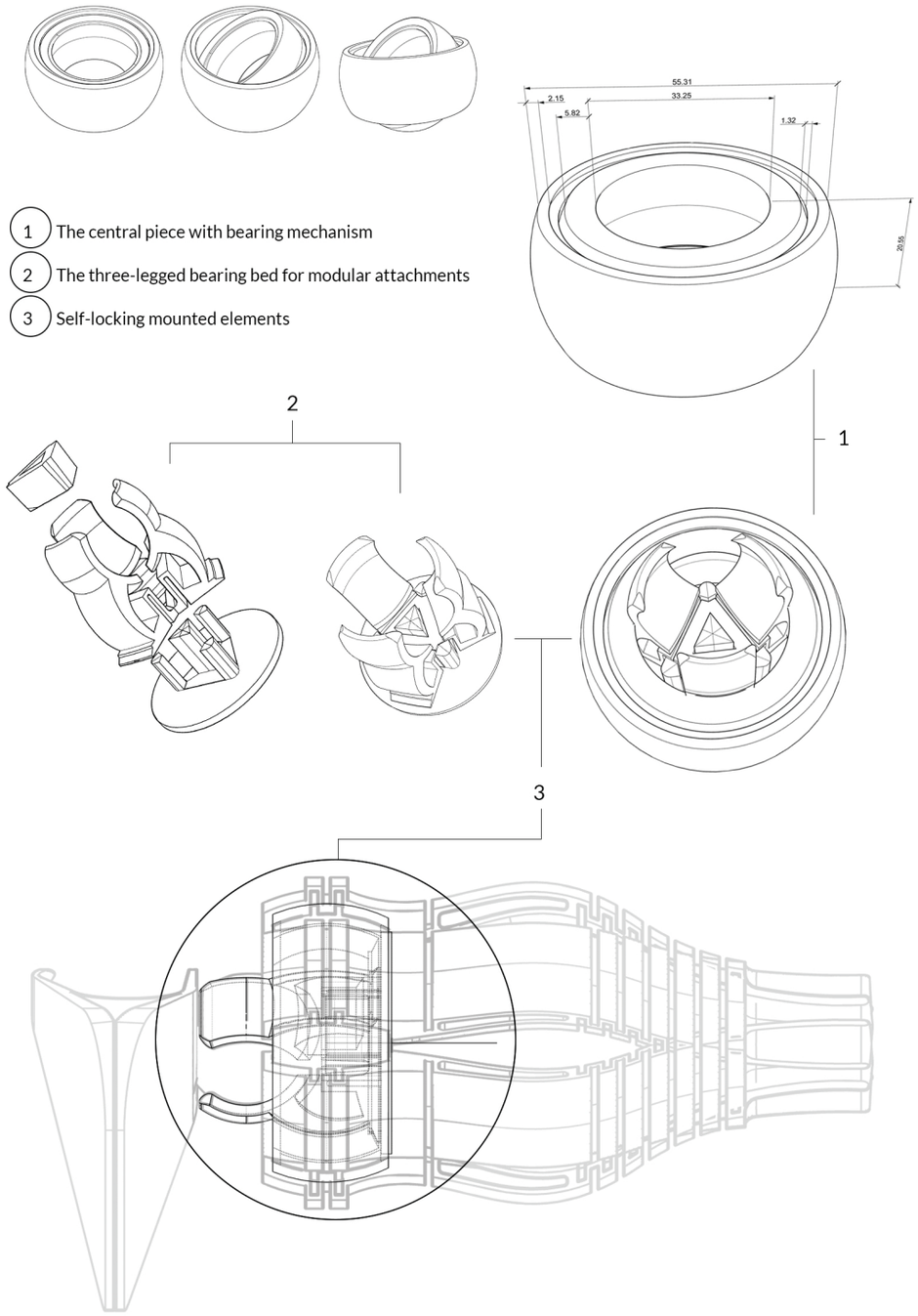


Figure 39: The main elements of the modular central piece.

Figure 36: Flexible adaption on the elbow stump. Photo by Renáta Dezső.

Figure 37: Modular element for card games. Photo by Renáta Dezső.

Figure 38: Flexible adaption for card games and support. Photo by Renáta Dezső.

Figure 40: Close-up of the modular attachments. Photo by Marcell Kazsik.

for usability testing as well. It is essential to acknowledge and illustrate the reason behind this. In some development phases there were obvious opportunities to try out another CAD model and/or a new 3D printing method, or just to take the findings for further testing and discussion.

The primary and secondary data of information both affected the evidence/artefact development. Primary knowledge already publicly exists on 3D printing. I also had several years of experimenting on various desktop printing to have primary sets for constructing research of the details.

Printability issues in the design to adhere:

- Applying a flat surface on each element for the initial layer defining the built orientation to ease the printing is a simple task that turns into a complex problem in connection to a biological form of a human body.
- FDM printed parts may require support structures to print successfully since a new layer is built upon a solid scaffold. The goal was set to model features on the prosthesis that does not require support with overhangs that are less than 45 degrees. As an effect, the printing time is shortened, and it is without detrimental impact on the surface from the support. Also, the post-processing time is shortened, which allow fast prototype testing time around. As far as the aesthetic side is concerned, its result is a visually different shape than a form from subtracting or moulding technologies. Therefore, it was not merely a technical and functional decision but also a designer issue since I decided to develop the form representing the attributes and aesthetic of the technology.
- Topology optimization means using an optimal method to minimize a part's mass while maintaining structural integrity constrained within a set of limits of printability. The optimization during various stages of the design process allows a more detailed design to be obtained. Since it is not a 'one click' process, the functional prototype testing process was easily aligned with the effort of optimization.
- Interlocking printing assemblies with moving parts in a single built. The orientation of the assembly on the built platform is affected as well.
- Lattice hinge design to improve the flexibility of the solid plastic material. Lattice hinges are a set of parallel, overlapping cuts that divide a solid shape into thinner, linked sections in an array of parallel divisions that determine flexibility in the material properties by geometry. They also affect the orientation of the building platform.
- 0,3-0,5 mm clearance for interlocking fit between elements
- 1,2mm minimum wall thickness in a single wall
- Easy assembly, easily mountable mechanism
- In FDM technology, the minimum future is<2mm; the desktop printer does not allow more minor details and precision models.

The transactions with the three-dimensional data were produced, shaped in turn by Luca's personal experience, the designer's ideas, and the analytic procedures of the research. The knowledge is the outcome embedded in the data of the artefacts affecting the transactions within the design and the social world, shaped by the methods of co-design inquiry for a 3D printed prosthetic artefact. Analysing the design process from contrasting angles communicates the complexity of the subject, encourages the exploration of alternative strategies in the design and also stimulates the sensitive appreciation of complexity and variety as Coffey and Atkinson suggest: 'The more we examine our data from different viewpoints, the more we may reveal-or indeed construct-their complexity' (Coffey and Atkinson, 1996).

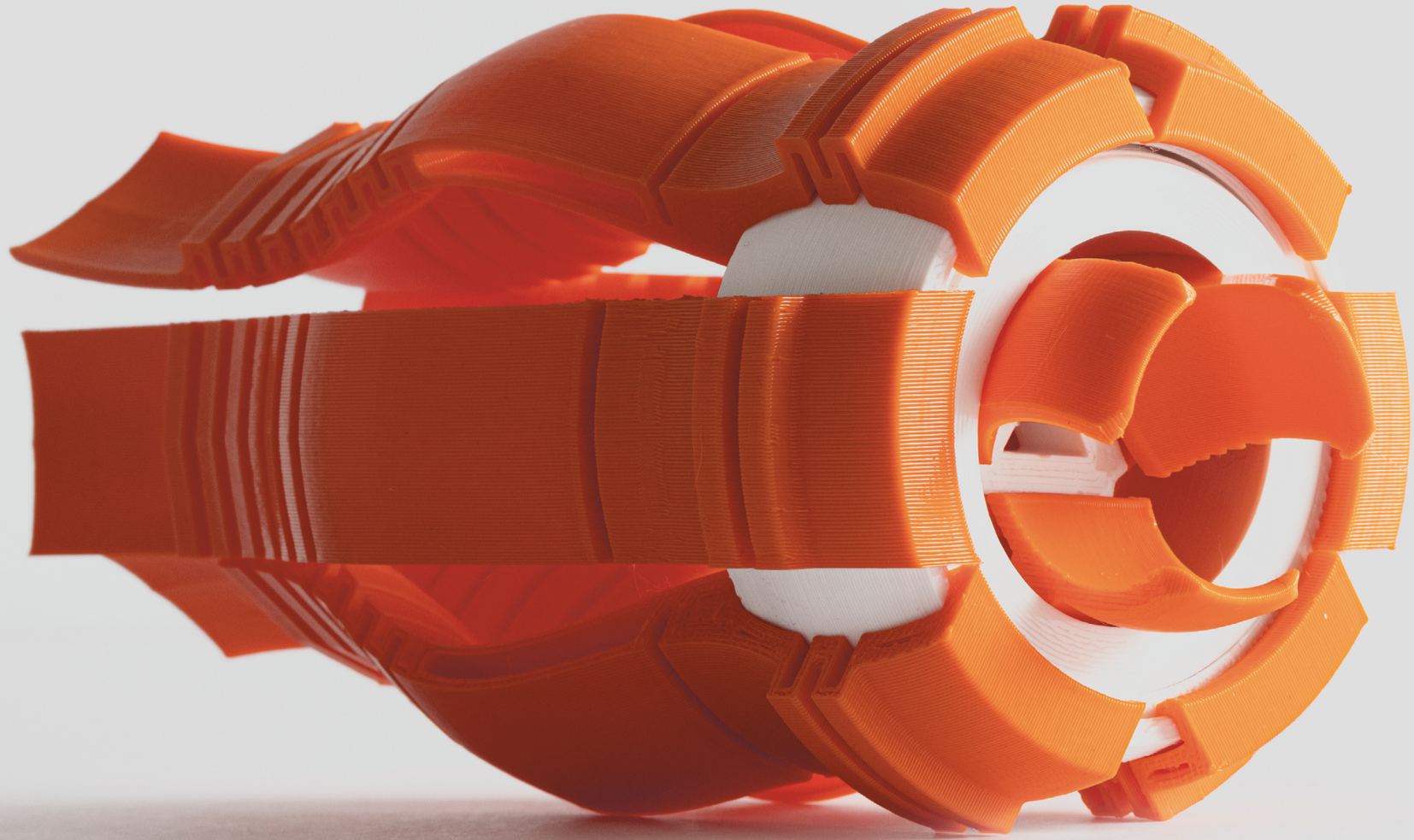
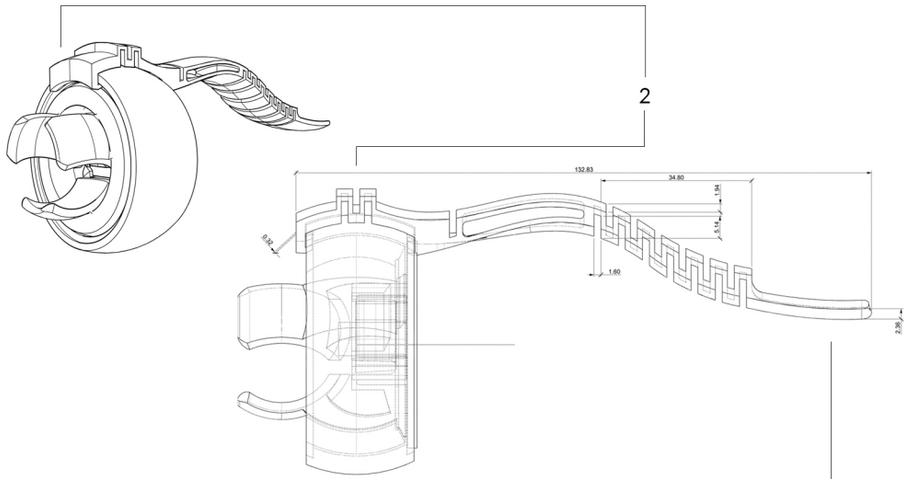


Figure 41: The modular grasp basic structure 3D printed and assembled. Photo by Marcell Kazsik.



1 The side element with flexible forming

2 Attachment to the central piece

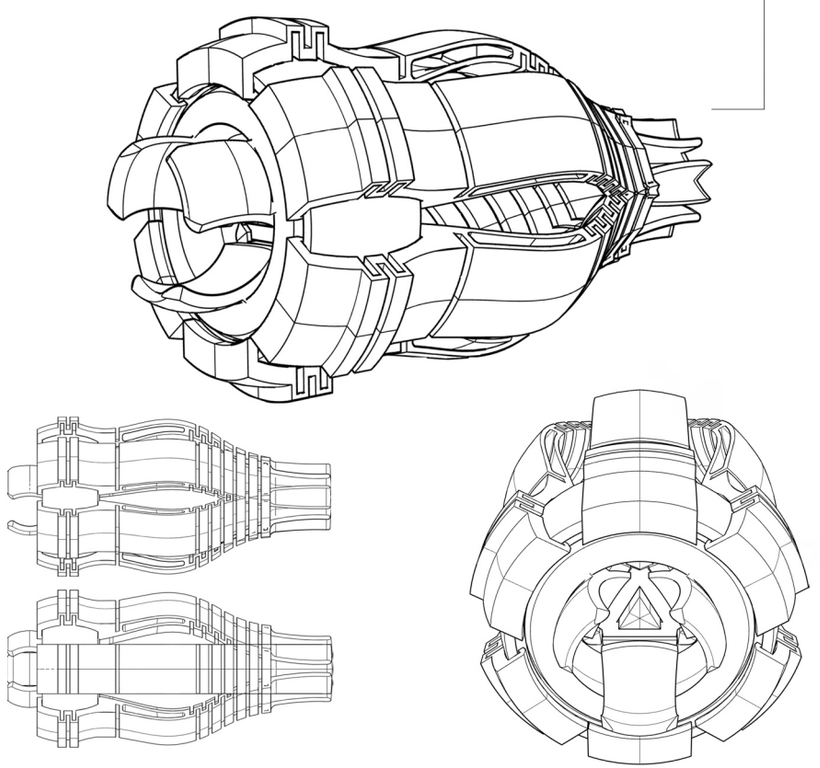
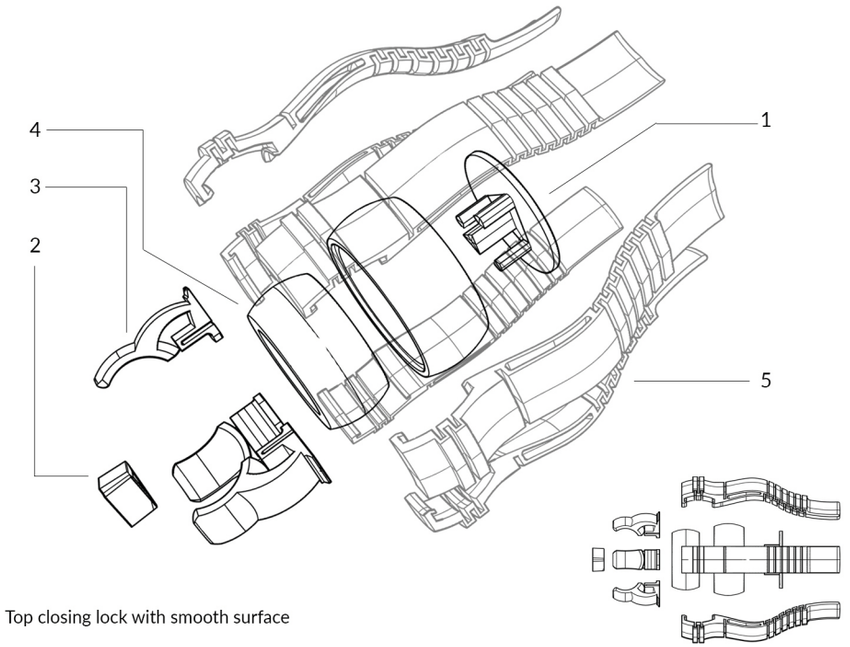


Figure 42: The modular grasp basic structure assembled.



1 Top closing lock with smooth surface

2 Bottom locking element

3 Modular bearing bed with three interlocking elements

4 Central bearing element printed in one

5 6 flexible side elements to be locked on the central bearing shape

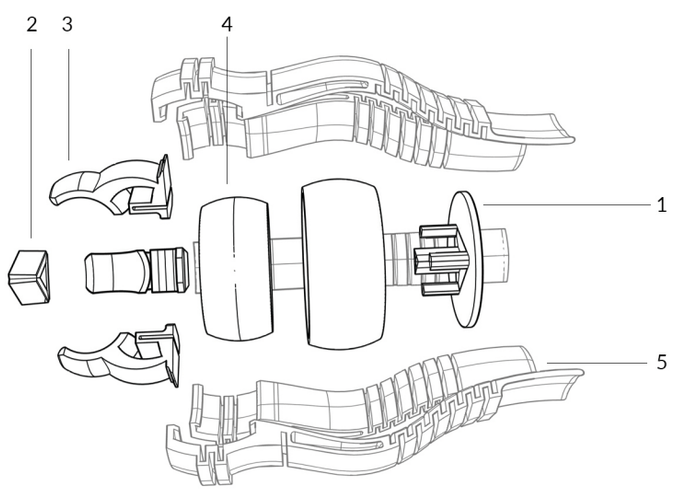


Figure 43: Exploded view of the central part of the modular model

Figure 44: 3D printed modular grasp central pieces with attachments. Photo by Marcell Kazsik.

Figure 45: Prosthetic prototypes are waiting for testing. Photo by Renáta Dezső.

Figure 46: Luca Szabados testing the prototypes. Photo by András Ladocsi.

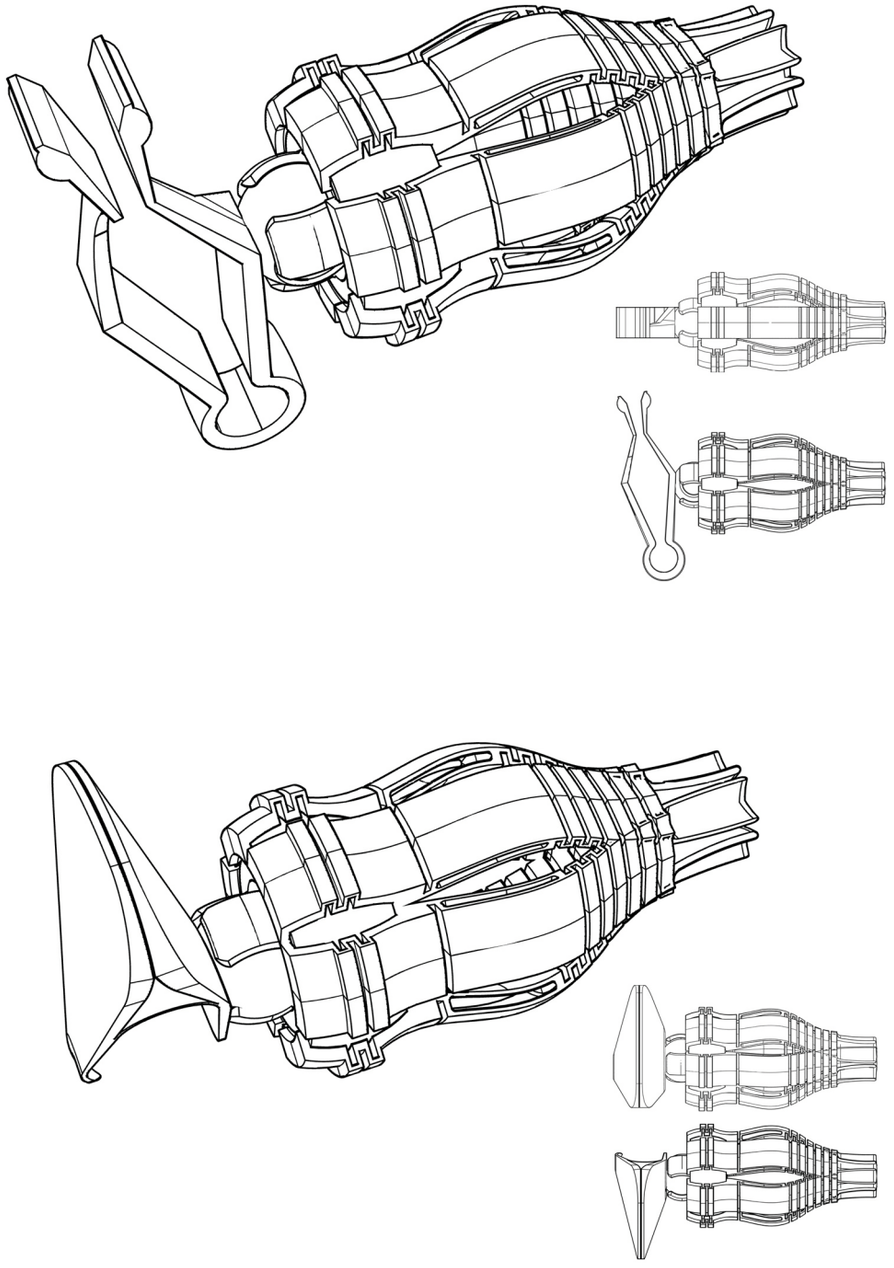


Figure 47: Two modular grasping elements attached to the central piece.

Figure 48: 3D printed attachable forceps. Photo by Marcell Kazsik.

Figure 49: 3D printed attachments. Photo by Marcell Kazsik

Figure 50: 3D printed forceps positioning. Photo by Marcell Kazsik.

co-design process to co-Ability concept

In this chapter, I reflect on the methodology of the design process, on what was done during the making and the testing processes. The thoughts and reflections here follow an earlier logical initiation already described in the previous chapter. Co-design was not a pre-selected, desired method at the beginning of the research. It only appeared by considering a specific design territory that combines craftsmanship and digital technologies driven by disability studies, but as it turned out, co-processes could initiate a new epoch with immense effects on the everyday life of the 'common person'. My interest has grown in understanding what could happen if we considered that cultural artefacts were produced by those no longer invested in maintaining human superiority in culture and politics? With the methodological approach of the co-design framework, I point to the junctures where technology, bodies, and cultural theory intersect. The presented co-design processes account for a decentralised soft assembly in which disability, technology, and design act as equal partners determine co-Abled formations.

Working with Luca, we became partners in design development to find solutions with a shared goal and with our own specific skills contributing to the design process with solid constraints of direct cooperation (Visser, 2006). At our first meeting, Luca's initial responses instantly clarified that my design practice greatly relies on her feedback and her specific needs. During the rapid prototyping of designs in recent years, amidst a wide range of social problems, co-creation and coproduction approaches developed for innovation to incorporate the user's needs in workaround solutions (Bessant and Maher, 2009; Bevan et al., 2007; Ehn et al., 2014). The interaction modality helped to connect the designed prototypes with Luca's everyday life settings, including non-verbal and often implicit personal and socio-political symbols. On the one hand, this design process with the prototypical exploration of future possibilities and practices mediated and supported the redefinition of a possible reality with new social, economic, or political roles for all society (Björgvinsson, 2008). Disability identity is already channelled in the form of language or symbols such as enacting, communicating,

or negotiating, all of which are often stigmatising indicators in social, everyday-life contexts. In this case, the parallel methodology to Discourse Analysis (DA) originating from linguistic studies with critical and semantical aspects in co-design led to a deeper understanding and innovative perspectives (Starks and Trinidad, 2007). The proposed cycle of prototypes and the design process present a 'plausible' set of concepts. Luca's viewpoint often added a contrasting account, moving the analysis further by connecting it all to the theoretical research work. The uniqueness of this doctoral research is embedded in the conceptual density of the chosen project because the validity of theories can change concerning contemporary social reality. Disability as a personal trait is dynamic. Disability studies and design culture progressively change, and so does digital technology. As various conditions change in such a case study project in the future, at any level of the conditional matrix affects the outcome. Barney Glaser and Anselm Strauss developed the grounded theory in the late 1950s. They undertook a scientific study of the human being with theoretical propositions to predict future events (Travers, 2001). Throughout the course of (designing) the prototypes in the case study project, the analytic approach was 'a general method of (constant) comparative analysis' (Glaser and Strauss, 1999), similarly to the Grounded theory in social science where 'the approach is often referred to as the constant comparative method' (Strauss and Corbin, 1994). The common ideology of design suggests that the designer develops the idea of an object and then anticipates the creation process in mind. The practical part is where the pre-computed and evaluated procedure is executed. To reflect on digital craft methods in making and observing objects and processes, I present reflections on my own practices. Instead of interpreting as a designer what is observed to conclude in focused terminal design development, it was the constant production of design prototypes that worked as a statement of the concept later verified by testing and discussing with Luca. While Luca did not always explicitly know how to translate her preferences into the object, I was the designer who completed the act of translation-interpretation by designing the prototypes further (Ventura and Shvo, 2017). This co-creation cycle was not only between the designer (me) and the person with a disability (Luca): the same cycle appeared in working with digital manufacturing technology. This methodological approach of co-design framework depicts the morphological interrelation of technology, bodies, and cultural theory.

After developing the 3D model from earlier data, the direct testing in the prototyping process began. Understanding a framework to analyse the role of emergent knowledge in digital craft practice was incipit rather than explicit. Many years of experience in additive manufacturing allowed me to do shorter turnaround cycles. These cycles are the co-creation phases with digital manufacturing. The implicit, pre-embedded knowledge of digital manufacturing makes the testing cycles almost subconscious; due to its physical nature, it is not easily transferred when the format of sharing is text-based, but the long printing hours and the errors in printing render it explicit again. Digital craft and the traditional craft technique are based on a collection of routines like sensing, acting, and moving. During these activities, the mind is predominantly focused on bringing an object into life with the help of direct contact with a specific material. The craft is built by action sequences performed in space and time, while the supplement is built on reliable environmental properties. It is like scaffolding upon external material structures with digital technology as an action-and-context-specific external control structure that guides the digital craft practitioner.

For example, in the traditional craft practice of glassblowing, a glass designer works in complex and effective feedback loops between movement and bodies of materials: the timing is inextricably interwoven with the glass transformation temperature, and the material is indirectly connected to the practitioner, and the material data is detected through the tools used.

Figure 51: Gergely Pattantyús glassblowing at MOME Tech Park.

As described by Andy Clark in his book 'Being There: Putting Brain, Body, and World Together Again', there are a variety of ways in which cognition might exploit real-world action so as to reduce the computational load for the mind (Clark, 1989). He means that scaffolding is where the bodily dynamics involve external memory-store from the material world and soft assembly, and then decentralised problem solving occurs. In order to learn about the world and the materials, specific actions are performed during the crafting exercise and the mastery knowledge itself is often acquired in an action-specific way with interaction modalities. Scientifically speaking, it can be viewed as 'sloppiness', 'chaos', or 'opportunism', but in the development, the risk of error and uncertainty has the essential function just as in science 'in the development of those very theories which we today regard as essential parts of our knowledge. These deviations, these errors, are preconditions of progress. Without 'chaos', no knowledge. Without a frequent dismissal of reason, no progress' (Feyerabend, 2010).

Figure 52: Gergely Pattantyús glass artist and lecturer and James Carcass glass artist and invited lecturer at MOME Tech Park, Luca Szabados prosthetic prototype testing at her workshop. Photo by Renáta Dezső.

As I described in the earlier chapter, a 'co-designerly' way of knowing through digital-craft work involves bodily dynamics and the use of simple kinds of external memory stores (Cross, 1982). To understand the working procedures better, it is essential to dwelling on errors, just as Richard Sennett states in 'The Craftsman' (Sennett, 2008). Studying the errors of the external material structures support change and development. It is implied that working with digital fabrication technology is necessary to have indecision and material learning. Error and failure are important, because that is the leading way of truly understanding a developing form or object.

Heidegger's famous example of the broken hammer provides access to the present-at-hand (as opposed to ready-at-hand) and hence to abstract philosophy and a scientific stance towards discussing the network between artefacts, entities, interactions, and systems such.

> 'The less we just stare at the hammer-Thing and the more we seize hold of it and use it, the more primordial does our relationship to it become, and the more unveiledly is it encountered as that which it is as equipment...' 'If we look at Things just 'theoretically', we can get along without understanding readiness-to-hand. But when we deal with them by using them and manipulating them, this activity is not a blind one; it has its own kind of sight, by which our manipulation is guided and from which it acquires its specific Thing character' (Heidegger, 1962)

Errors do not just render an 'invisible' tool suddenly visible, but they redirect the focus onto what matters in the situation. During iterative changes supported by errors, the practitioner often only remembers the present-at-hand situations with the design. This raises a few questions: how might a relationship between 'head' and 'hand' + 'materials' + 'tools' manifest itself in the context?

In the object-oriented discursive co-design actions described earlier, the interaction modalities with the material help shape the forms of the prototypes. At the same time, the prosthesis prototype also renders the maker conscious and shapes the person's thoughts by leaving the generally invisible elements visible when presenting 'errors' during the process. The ideal prosthesis, in Heidegger's terms ready-at-hand, is the one that fits seamlessly or invisibly into a meaningful network of actions, purposes, and functions. Being part of one's action becomes part of 'oneself', 'one's body', part of a domain of 'ownness' or 'mindedness'. Meanwhile, according to Heidegger's terms, the created discursive prosthetic prototypes in this process are present-at-hand, providing reflection, improvisation, and developments by delivering errors. The forms of the prototypes are not waiting there all along to be discovered, and they do not look biosimilar to an anatomical hand. The co-design process is an involved, embodied action loop in which key elements act innovatively through collections of moments ready-at-hand process.

Based on Heidegger's philosophy, there is a discussion about the double life of equipment, the tool in action when it is invisible, and the tool presenting error and rendering conscious visibility. I would suggest the two modalities should not be based on the existence of a tool or material but should be based on human perceptions. In the previous chapter, I analysed the parallel modality (animated vision and exploratory tool of touch) between exploring the environmental data and the self-awareness that can lead to understanding the world around us according to how we understand ourselves. The two dominant binary modalities are in opposition, cooperating in recognising information.

'Co-design assemblages allow us to ask important questions about power, authority and resistance. However, while the co-design process assembles a multi-componential model with a design goal, it also represents a formally unstructured attitude that is instead managed by a shared philosophical understanding. Co-Ability is a new concept and a new productive, ethical relation that is not a definition of how people work together with others towards a shared goal – instead, it offers an interpretation of how we, biological/artificial, human/nonhuman, elements/networks become relational in a complex manner that connects us to the multiple. In this condition, shared competence is a distributed phenomenon rather than an individualised trait. Our understanding of the actors involved in design practice will deepen if normative power is not exercised. The understanding of co-Ability is grounded on posthumanist philosophy and critical disability studies outlined by scholars such as Rosi Braidotti (2013) (2017); McRuer (2016); Goodley (2014) (2017); Goodley & Lawthom (2009); Campbell (2012); Wolfe (2009); Meekosha and Shuttleworth (2009); Shildrick (2009) (2015); Liddiard (2014); Mallett & Runswick-Cole (2014); Ranisch & Sorgner (2014). The concept of co-Ability contributed from the perspective of disability studies and that of design culture offer alternatives for the dominant 'humanist man' (Braidotti, 2013). The term co-Ability is not the opposite of the term "disability", nor is it the contradiction of ability. This term applies to the relational matter of our world. Many posthuman transformations already occur every day across the globe since our life is technologically mediated daily. Our physical spaces and the social spaces liaise by networked computational media' (Dezső, 2019).

Co-Ability is a transformative language engaging directly with the reauthoring perspective on social architecture and roles stuck in 'contested concept of humanity' to 'approach humans as embedded in a network of relations between humans and non-humans' (Trigt et al., 2016). It brings a new social ecosystem built on relational autonomy conditioned by the social relations in which individuals are embedded to enable life to flourish (Winance, 2016). Relationality means not to think beyond disability or opposition of humanity but to reconsider the domination of any elements and represent the reciprocal interaction in forms of meaning-making and sense-making in everyday practices.

How can the structure of embodied knowledge in perceptual awareness be related to body-centred human norms in society? By investigating the reciprocal relationship between new technology in prototype fabrication and unfolded new ideas, the notion of the spirit of posthumanism appears to be directly questioning how contemporary technologies contribute to the powerful social or philosophical repercussions in human life. The ways in which knowledge is formulated after the genuine question of what it means to be human. The politics of technology render it invisible and seamlessness to blend into the fabric of everyday life (Forlano, 2018; Weiser, 1999). It is easy to dismiss the material realities of technologies, including the ways in which they are entangled with human bodies, environmental resources, and political economies or the ways in which they embody our ethics and values. When the material realities of technology are explicitly studied, we can reconsider human co-evolution with technology that repositions and reinterpret what it means to be human amongst nonhuman actors. The relational posthuman model greatly expands our understandings of the multiple agencies of technology. There are related concepts of the posthuman perspectives that differ in many aspects, such as the non-human, the multispecies, the Anthropocene, the transhuman, and the cybernetics theories. By using the critical approach in posthuman studies to exceed human-centred norms, I address the repertoire of experiencing reciprocal connectivity in the Rosi Braidotti sense (Braidotti 2013). Posthumanism integrates human and non-human actors in the networks that share equal agency when it comes to participating in actions with shared competence. Liberal notions of autonomy are equally crucial in our value systems: responsibility, self-determination, solidarity, community bonding, social justice, and principles of equality supported by humanism. To bring us towards exploring co-Abled formation further, the interpretations of 'online' and 'oine', or a conscious–unconscious representations of the body, can help (Carruthers, 2007).

In the case study design process, the question is as follows: why do we want to make a prosthesis that looks biosimilar to an anatomical hand-worn long-term when the actual function does not need such a complex form? Is it connected with our mental representation of the body considering another person or ourselves?

'Since 1905, when Bonnier first introduced the term "schema" to refer to the spatial organisation, almost all neurologists have agreed on the existence of mental representations of the body' (Vignemont, 2010). We have a radical recognition of bodily functions (e.g., health span, longevity), cognitive and emotional capacities (e.g., intellect, memory), physical traits (strength, beauty), and behaviour (e.g., morality). On the basis of the affirmation of specific traits, there is the relational matter of considering another person or our self' (Dezső, 2019). The self-aware knowledge of our body is linked to the body-image, which is a mental model joined to all affective, cognitive type elements traced in our body (Molinari and Riva, 2004). 'In addition, Vignemont (2010) says that the body image can be applied both to one's own body and to someone else's body' (Dezső, 2019).

After Ungerleider and Mishkin established the well-grounded theory of the Perception–Action model (Mishkin et al., 1983), Paillard distinguished the main dualistic aspect "the identified body" (le corps identifié) and "the situated body" (le corps situé) (Paillard, 1991). The body-image is connected to our perceptual body identification and recognition, and based on it, the body parts are judged predominantly in a visual manner. We build the concept of the whole by including information on the organisation of the elements that are relatively structurally stable (Dijkerman and de Haan, 2007). Changing a visually stable body image is fairly difficult, as it is preserved even when a situation is changing the actual body (Vignemont, 2010). Most commonly, the natural changes appear with age, such as the change in hair colour, tone of body parts, etc. Traumatic changes like amputation call for a more radical restoration of body image 'applied both to one's own body and to someone else's body'. Luca is missing her upper limb by a congenital disability, and the concept of her own body image is developed in self-recognition through her personal history at an early age. An external viewer's self-body image concept develops differently than Luca's, so when one recognises that the organisation of Luca's body parts is different from their own structure, they tend to assume the need for radical restoration with a biosimilar looking prosthesis. In this analysis, the 'body-image is related to the body-centred human norms in society. Ideals of bodily appearance that are impossible for most people to achieve are cunningly promoted as the necessary norm, thus condemning vast populations to oppressive feelings of inadequacy that spur their buying of marketed remedies' (Bordo, 1993; Dezső, 2019).

Luca's refusal of a classical prosthesis was not based on looks or on how it helps her visually blend into society. Her response focused on bodily experiences such as weight or how a prosthesis is disturbing and causing changes in body movements or brings discomfort. Her answers lead to viewing the action-oriented body representation that is constantly updated by an action called body-schema. The information about what is 'necessary for body motions such as posture, limb size, and strength' based on implicit elements traced in everyday actions (Dijkerman and Lenggenhager, 2018). In the complex phenomena of body-schema, we often encounter the 'motocentric' knowledge when an embodied; embedded agent/object/prosthesis prototype is acting as an equal partner in adaptive responses to the environment, which draws on the co-Abled resources of mind, body, and world. It is intimate correspondence feedback and interactions that follow the rhythm of the object and the body.

With the help of the various data embedded in the artefacts, the prosthetic prototypes for this study were collected over a period of five years. In the early context of the case study – during the first year of the co-designing process – we were unaware of co-Ability theory being embedded in the process (Glaser and Strauss, 1999). After becoming aware of co-design mechanisms and the critical disability studies, we discussed co-Ability in the design context with Luca. 'Memory note taking' was in the digital design and remained close to the design process. In this period, the article on co-Ability practices was published at the 8th biannual Nordic Design Research Society (NORDES) conference at Aalto University, Finland (Dezső, 2019). Following the process, more abstraction was built directly upon the prototypes revisiting cycles to be checked and refined by designing further prototypes.

I defined four sets of elements that interact on three different levels 'to articulate the co-design assemblage in layers of theories, competence and body of entities that establish a principle of relevance for knowledge' (Dezső, 2019).

'Keyplayers' as non-static and changeable entities in the co-design process:

- The disability entity is based on Luca bringing her implicit knowledge of bodily mechanisms. On the disciplinary level, she represents the complex socio-political aspects of disability.
- The entity of Design culture embedded in the designer participating with First-Person-Perspective (1PP) (Höök et al., 2018; Tomico and Wilde, 2016; Tomico Plasencia, O. et al., 2012; Wilde et al., 2017). As a disciplinary, I add design culture in the doctoral research. 'Within RtD, the researcher and the objects created are entwined and cannot be separated, establishing knowledge through this relationship' (Isley and Rider, 2018).
- Digital technology represented by the desktop 3D printing process that has the potential of personalised low-cost object production in digital fabrication. On a disciplinary level, it was imperative to add computational technology and human-computer interaction (HCI) into the discussion (Dourish, 1999; Zimmerman et al., 2007; Zimmerman and Forlizzi, 2014).
- Artefacts as a media – mediating messages through the material reality of a prosthesis. The prototypes embodied a collection of mediated messages addressing social, cultural and technological insights in the artistic artefacts. Usually, the created forms take on existence as an entity whose meaning is determined by the character of the theoretical gaze to which it is subjected and by the explorative movements that are in use. Adopting the perspective and experiences of a digital craftsman, it differs from an observing interpreter of objects.

No partners in key elements alone had the independent knowledge to develop the prosthesis prototypes. The morphological suspension of distinctions in established institutional and professional boundaries in a design project with several key players such as designer and user, or technology and human, artificial and biological can generate novel approaches. Actor-network researchers (Dolwick, 2009; Latour, 2007, 1999) suggest that socio-material political assemblies collectively intervene with people, the artefact, and the process. All key players are small independent actors in a relationship for agile and open collaborative innovation supporting shared competencies.

It would have been more complicated to manage fast turnarounds with complex professional printing technology. The small independent infrastructural level stabilised the cultural practice with open innovation, and stability was brought by not being expected to become entrepreneurial with an extensive, corporation-like system. The morphology of co-ability can be described by the changes of the network-shaping character in certain situations (prototype creation, prototype testing, discursive reflection, literature review etc.). The morphing is activated by one or more members in a continuously transactional network. In this case study, the network and the described morphology is aligned with similar

aspects of disability and co-design, both distinct, unstable in context and in time, presenting a never-ending process allowing divergence and change in key aspects.

As it is presented in this section, the research theory on co-Ability and the design activity constantly informed each other through the application of design practice and reflective discourse.

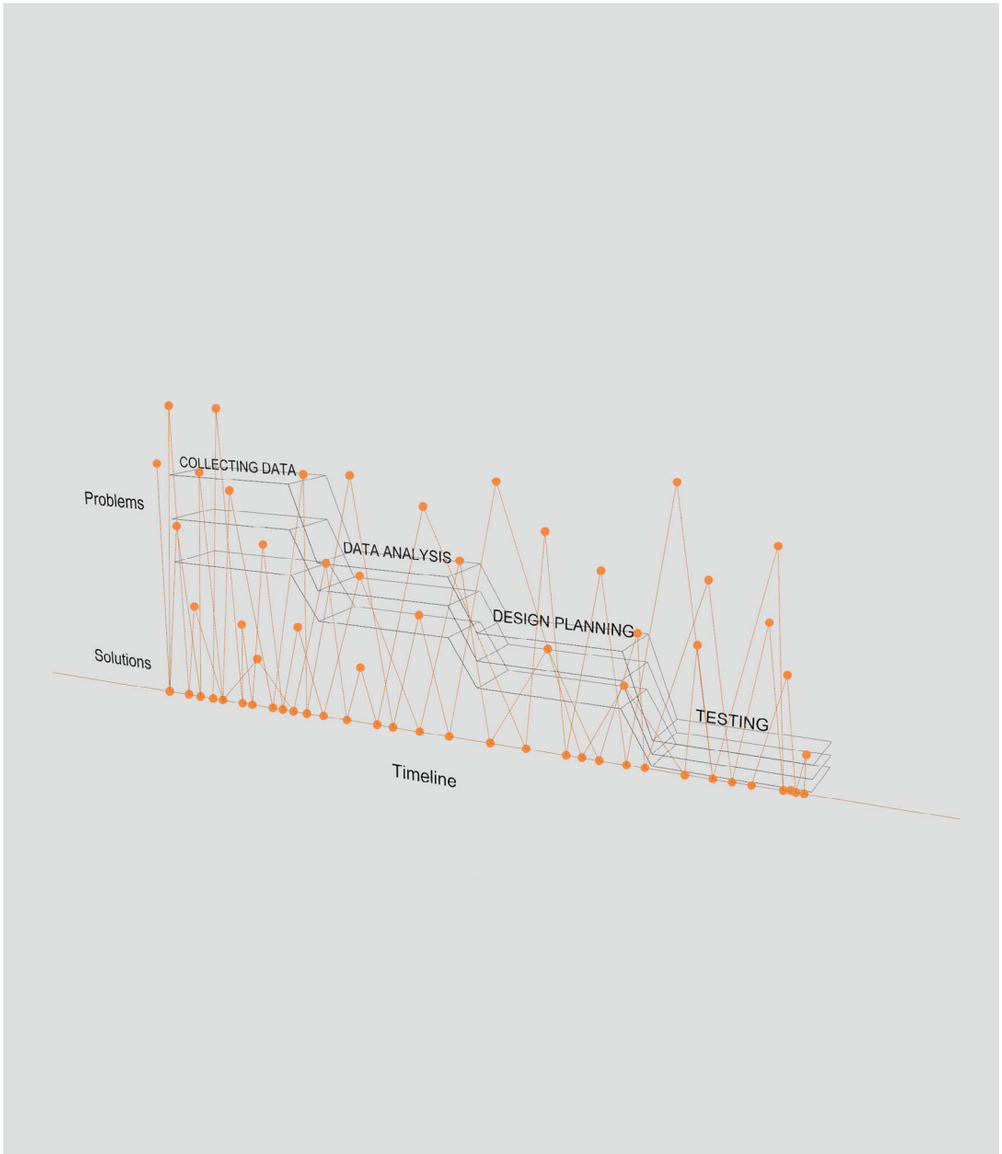


Figure 53: Pattern of the cognitive activity of the designer in co-design - 'jagged' line opportunity-driven approach (Conklin, 2005).

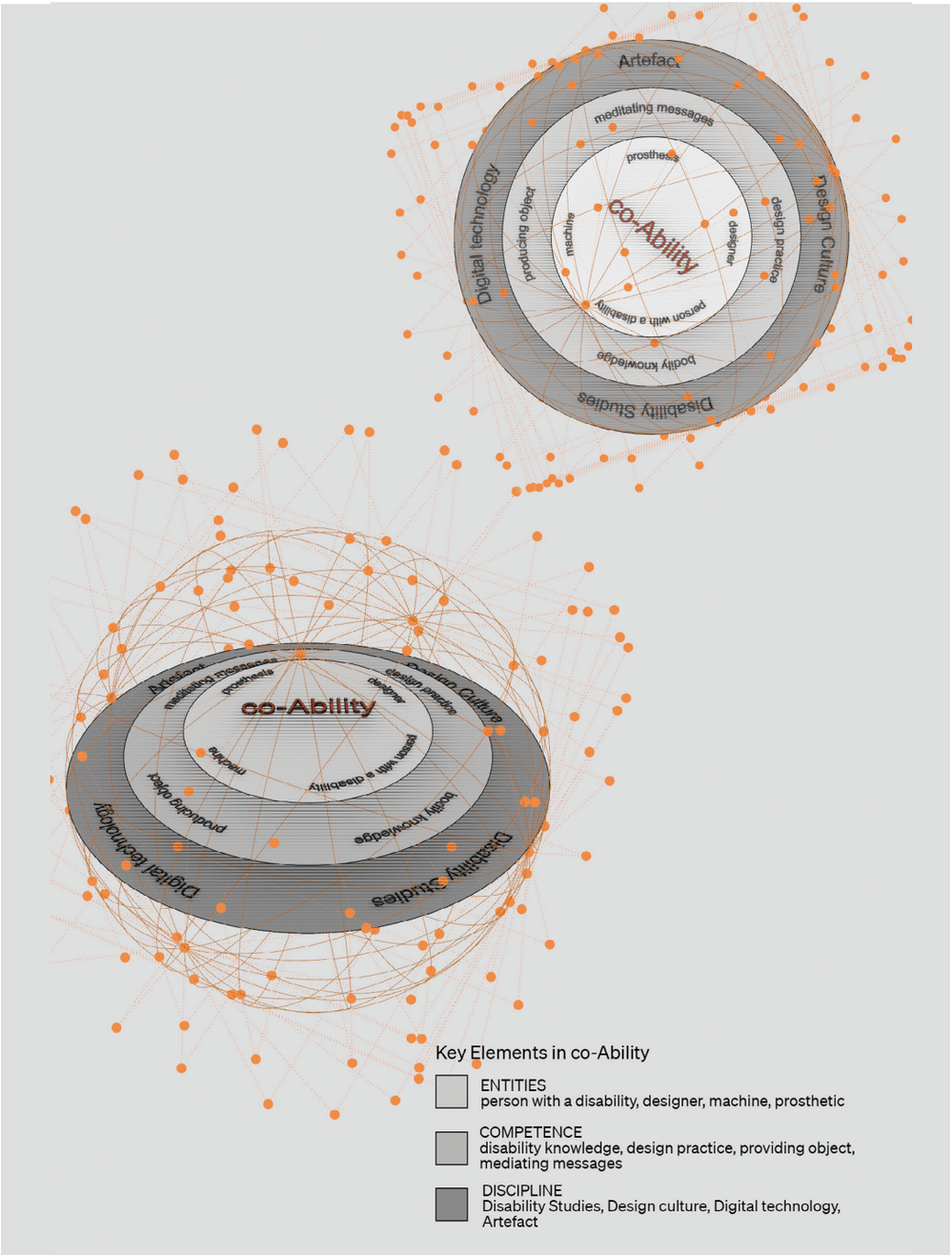


Figure 54: The key players, co-Ability assemblages in levels of disciplines, competence and entities. The yellow dots and the trajectories of the movements represent the patterns of activity as 'jagged line opportunity-driven approaches' described in Concklin works on co-design approaches (Conklin, 2005).

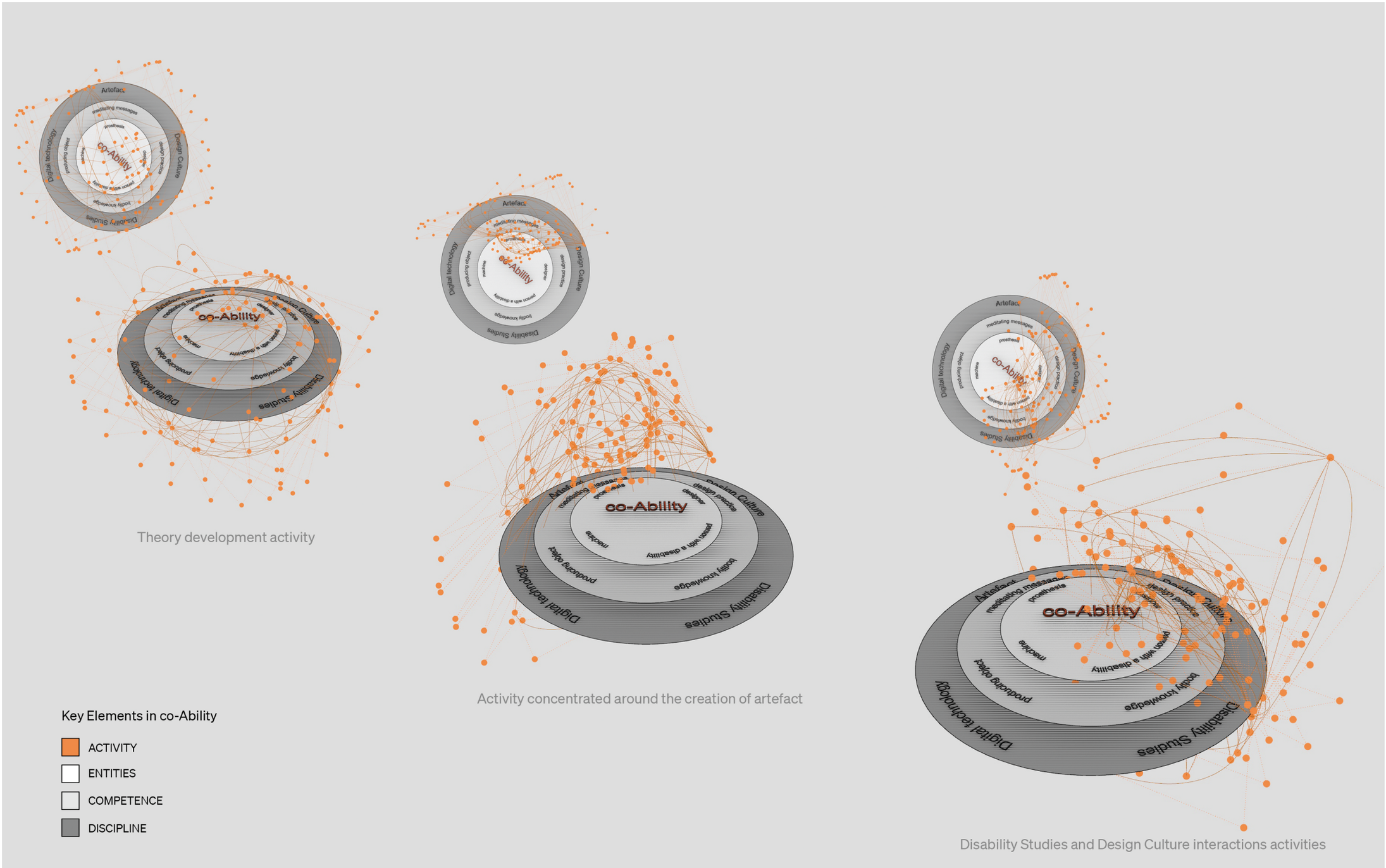
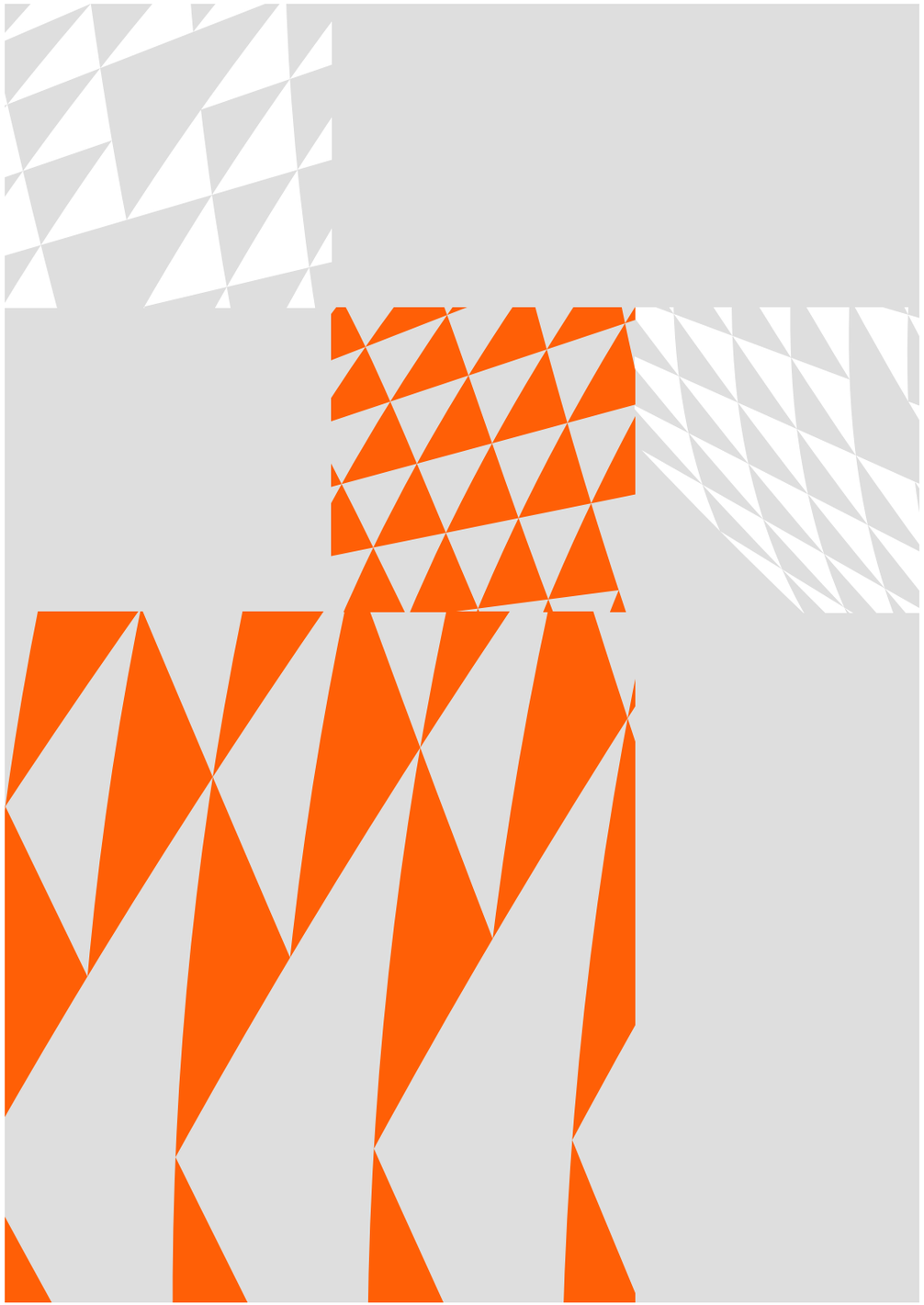


Figure 55: The morphologically changing aspects represented in co-Ability assemblages.



Chapter IV.

Analysis of the theory development

The goal of the analysis is to understand how the data of the artefacts (prosthetic design prototypes) is supported to create and enact identities and activities, shedding light on the creation and maintenance of social norms. The co-design case study process served as construction for understanding the personal identity of a disabled person and group identities of disability in society negotiated in social and political interactions. The search for essence as the main goal draws the research to theory development in exploring the phenomena instead of creating a market-ready product design.

To construct the narrative of the studied phenomenon co-Ability, I gathered new data while developing the testable prototypes. I kept meeting Luca to test the prototypes, discuss our point of view, and teach at the university while collaborating with different stakeholders on disability studies. The term co-Ability evolved as a self-evident reality after I dived into posthuman studies within disability studies and reflected on the co-design process. We were trying to describe co-Ability from various perspectives in discussions. Its meaning has enriched and has become more complete each time. Presenting the developing material at scientific conferences has helped me review the phenomenon from various angles (somaesthetic, design education, artistic research) and has helped me gather review feedback through different publications (conference papers, articles, exhibitions).

The self-imposed limitation on the design practice was based on the scientific bias to understand/respectfully apply existing theories in such a complex phenomenon. The focus was not completely/directly on the design but research activities. Instead of completing the research in a shorter timeframe for a general design project (research for design), I waited and resisted the temptation to create a quick and sufficient design solution for a possible trending product. While the categorised information gathered could effectively support critique and enlighten problematic patterns in design culture relating to disability, it could also carry supporting quality for educational programs and future designers to understand related arguments. The concern for appropriate data is in the interactions accomplished with the disabled person, the object/prosthesis in object making/cutting, or in this case, also the interaction with the technology. These data embedded in the artefacts are also 'natural' and 'artificial' at the same time, as it involves bringing real people's social situations into the project, 'naturally' generating action-oriented data. The involved persons' bodies are real, and the prototype is usable, and it is not merely an aesthetical representation of an object or a visual concept. The research questions define the criteria for including prosthetic design in a corpus of the research. In this case, I would suggest that generating a corpus of research data for evidence is equal to generating a corpus of design artefacts. As a prelude to the action orientation, there is a need to do and redo the initial design until the designer becomes familiar with the data in it. It is a process similar to craft practice. A whole range of action orientations is likely to be displayed in prototypes. The focus was only on what is relevant to the research question at hand, generating discursive situations and interactional strategies. As for the many probes and re-probes, it seemed a good idea to explore the rhetoric in action orientations.

At this point, the strategy began generating appropriate outcomes for a discursive analysis. Each major prototype requires a description of the action orientation of what is being acted in co-design sessions. In artistic research, I believe it is not enough to simply describe what is being said, instead, it should be combined with an interpretation of the flow of the project, so active communication to the viewer is inevitable. The prosthetics were developed with the goal of a substantive, value-based exchange. The primary function of the prototypes was to communicate and provoke ideas through the object. As the discursive instruments, the artefacts established a dialogical relationship with Luca Szabados in the case study. Later on, they will hopefully be subject to an exhibition for the general public. A complete assessment otherwise requires further terminal design intention, something that is excluded from this research. The ambiguity of the object, 'suggesting issues and perspectives for consideration without imposing solutions' since the 'user', is not the only thing invited to raise topics or ask questions. The prosthetic artefact in this study combines the contextual and relational ambiguity suggested by Gaver et al. 'Contextual ambiguity can question the discourses surrounding technological genres, allowing people to expand, bridge, or reject them as we see fit. Relational ambiguity, finally, can lead people to consider new beliefs and values, and ultimately their own attitudes' (Gaver et al., 2003).

Figure 56: A whole range of action orientations are likely to be displayed in prototypes

Practically, the final prototypes are both parts of the research and knowledge generation. The design development was not focusing on creating a terminal design for subsequent commercial use. Hence in the case study, while the idea is embedded in the prosthetic prototypes, there is a significant differentiation between the 'user' and the 'viewer'. Needless to say that the discursiveness of the object points to the viewer's associations while the prosthetic is used by a person with a disability. The general notion of discourse around the prosthesis allows a comprehensive message to be contemplated, and it also helps people other than those who use the prosthetic understand it. When a non-bionormative prosthetic design effectively communicates the notion of an idea, the viewer may effortlessly internalize it and reflect upon it, even if the designer's/researcher's desire causes a change in thinking. The viewer is not forced to have a different perspective because the designer is not dictating that. In this case, disability is not taking part in communicating design excellence in the power of care. Still, it cooperates to represent substantive ideas with the topical complexity of disability relevant to individuals and the public. Ultimately, the new perspectives of considering co-Ability instead of human-centred norms 'may result in changes in behaviour and action, changing the world even in the smallest ways at the level of one individual, but also perhaps with collectives and with ripple effects even influencing societal structures' (Dezső, 2019; Tharp and Tharp, 2013). Why is a discursive prosthetic design so significant to connect with the general viewer?

To understand its effectiveness, I recall Masahiro Mori's concept, known as the uncanny valley. This phenomenon describes a person's response to robots that failed to attempt a human-like appearance (Mori et al., 2012). In fact, the theory recently has attracted interest in robotics and cybernetics. Mori introduced the scale from affinity to uncanny sensation when he recalled a situation meeting with a prosthetic in which '[the] hand that looked real at first sight is actually artificial, we experience an eerie sensation'. In the situated design discourse, the appearance of a prosthesis, especially in movement and the perceiver's affinity, are interconnected. Mori's suggestion to 'creating a safe level of affinity by deliberately pursuing a nonhuman design' (Mori et al., 2012) is met with the proposed aesthetic and the presented prosthesis.

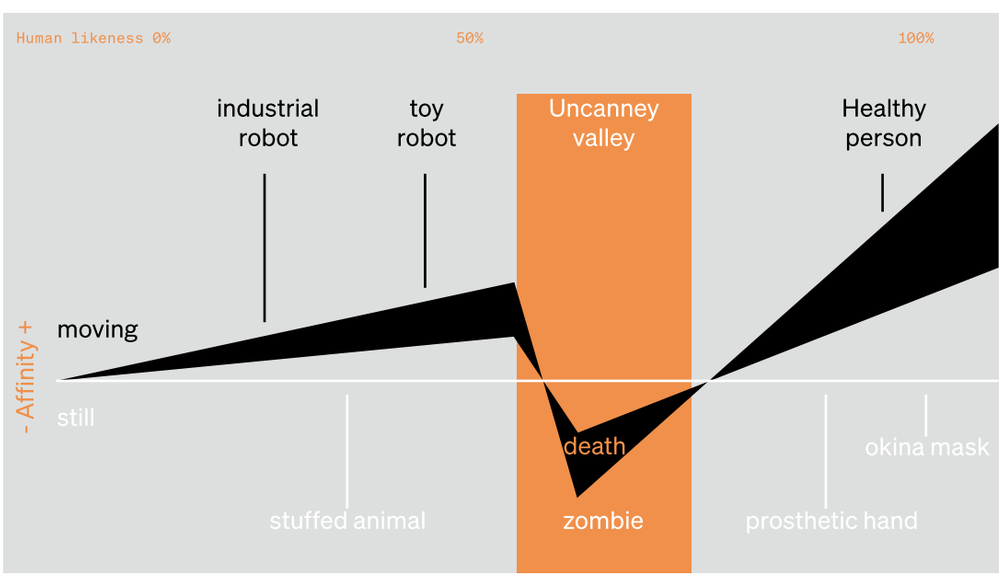


Figure 57: Co-design assemblages in grey, co-Ability morphologically changing aspects in pink' (Dezső, 2019)

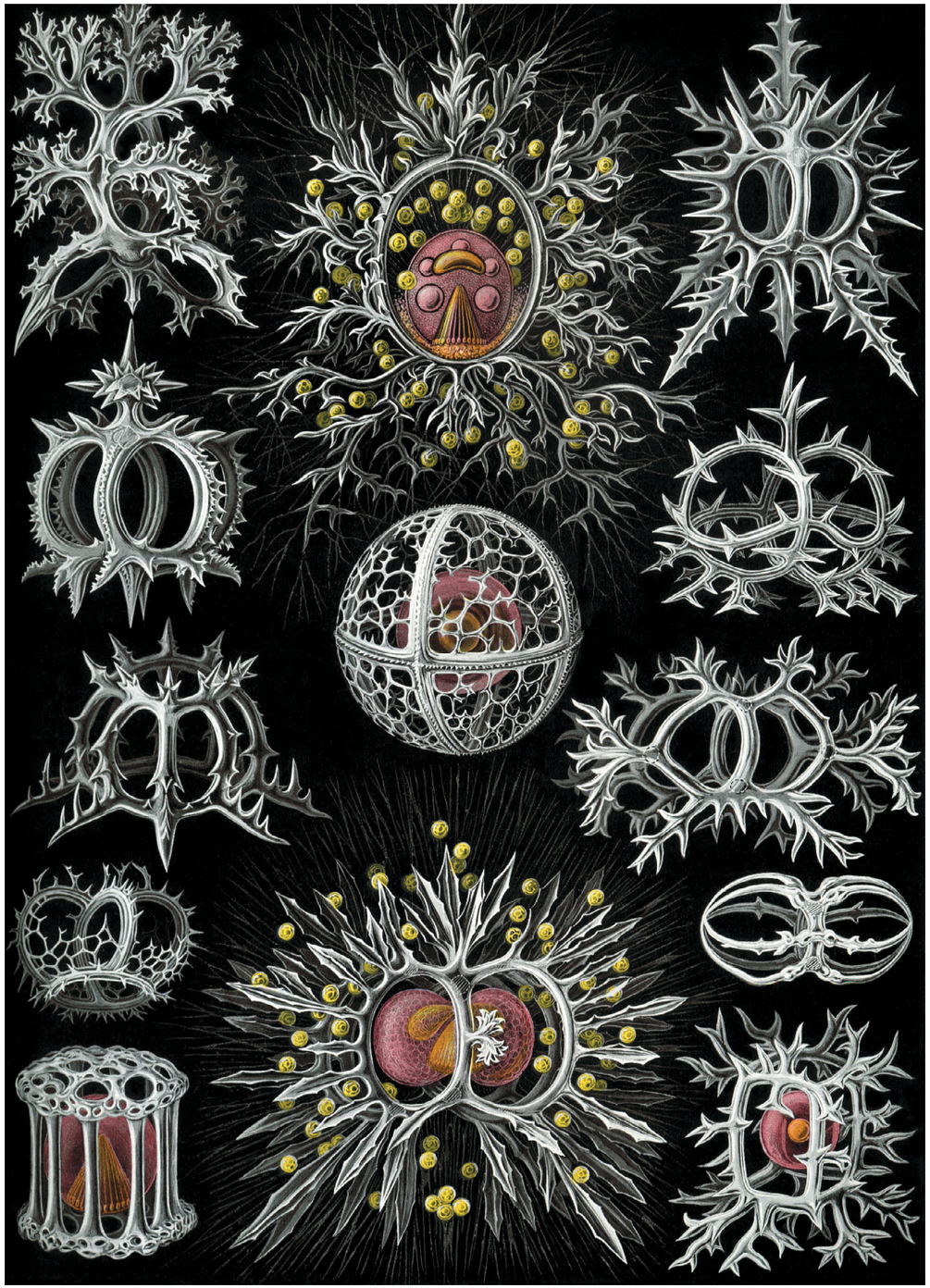


Figure 58: Kunstformen der Natur" by Ernst Haeckel (1904), plate 71: Stephoidea (From Wikimedia Commons, the free media repository)

The connection between the artefact and the viewer's emotional response is amplified by seeing a non-bionormative prosthesis. At the same time, the intention here was to enter the knowledge generated by the research into the discourse.

How can discursive design research be presented to the viewer? How do I plan the encounter with the audience? How do I help them view the project's argument – instead of a result of a terminal design production – as a masterpiece of the best prosthesis? Discursive designs 'function (or can function) in the everyday world offering utility, but it is their discursive voice that is the most important and ultimately it is their reason for being what matters.' (Tharp and Tharp, 2013). The doctoral dissertation produced here is for the reader, which does not rule out them being a viewer of the exhibition at the same time. However, the large textual documentation of the research is intended for 'Internal focus/audience' (designers and academics) (Tharp and Tharp, 2013). To provide an intellectual service to the viewers, an art installation will be a comprehensive representation for external audience with broader cultural background. Calling art to represent scientific results in 'second-order consequence' and to affect general culture has a long and respectable history. Art contributed extensively to the constructive process of how we understand the world we live in by celebrating, promoting and communicating science. Ernst Haeckel's (1834–1919) contributions to the visualisation of the Darwinian theory are one of the most admired examples where scientific principles dictated artworks, resulting in explanatory effect and successfully influencing the general visual culture for centuries. Furthermore, a more contemporarily example would be the virtual and real data sculptures, augmented reality tools or images projected into space for visualisation represented in the extensive work by Albert-László Barabási (Barabási et al., 2020). In this case, the designer/artist can be called a data visualisation research specialist, who represents visually complex network data prepared by an interdisciplinary group of physicists, biologists, or computer scientists.

Prosthetic prototypes represent the tangible chain of thoughts resulting from the design synthesis of knowledge and research question with the central links of the method. The novel method determines an appropriate validity of the outcome, or in other words, the understanding of co-Ability. Reflecting on the study's process, there was no intention to analyse the materialistic world, as design practice was not for rational problem-solving. The new realities of co-Ability were understood, and discursive prototypes were made to discuss the new reality of the concept (Koskinen et al., 2012). In this case study, it is not the final artifacts that are rigorous but rather the process documented by the prototypes; in fact, 'rigor in research is the strength of the chain of reasoning' (Biggs and Büchler, 2007).

Documentation has been done during research in a supportive and retrospective capacity as well, and at the post-design stage of the research dissemination, it was assembled into an annotated portfolio (Gaver, 2012), a conference paper and presentations (i.e. 8th biannual Nordic Design Research Society Conference at Aalto University; Design Culture & Somaesthetics Conference at MOME; Fifteenth International Conference on Technology, Knowledge & Society at Barcelona; Thirteenth International Conference on Design Principles & Practices at St. Petersburg University; D'Art: Teaching Artistic Research Conference in Vienna and 5th Disability Studies Conference in Budapest), or university lectures at MOME or as an invited lecturer at Universität für Angewandte Kunst Wien.

In these circumstances, me as a designer would no longer be viewed as an individual who creates objects for the healthcare industry but as a communicator who seeks to discover convincing arguments by means of a new synthesis of objects and words. In return, this could shift attention to disability issues. "To discover new relationships among signs, things, actions, and thoughts is one indication that design is not merely a technical specialization but a new liberal art" (Buchanan, 1992).

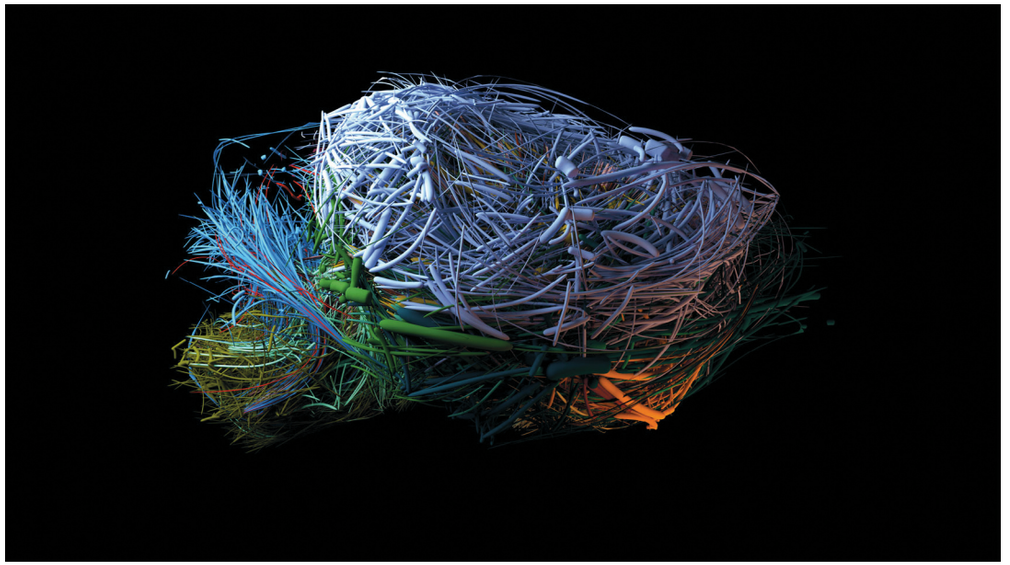


Figure 59: Image by Alice Grishchenko and Nima Dehmami. Jose Brum and Emma Towlson created the network. Mouse brain network featured in WonderNet - (Virtual) Physicality of Networks. Image created by Mauro Martino, an underlying network created by Jose Brum and Emma Towlson from data from (Oh et al., 2014).

Figure 60: The co-citation network for Nature. More than 88,000 papers published by the journal since 1900 are each represented by a dot, coloured by discipline. Papers are linked if another scientific article (of those indexed in the Web of Science) cites both; the dot size reflects the number of these co-citation links (Gates et al., 2019). Design by: Alice Grishchenko, Mauro Martino (IBM Research), Claire Welsh

Conclusion

Interpreting or bringing it all together

To study the trajectories between Disability studies and Design culture perspectives, the application of practical design experimentation 'through' a single case study like prosthesis design with situated discursive co-design method proves to be a reliable instrument. The dichotomous interactions between artistic/design/craft practice and scientific research played within the forces and relations of production (knowledge and artefacts) not only transform each other by applying the "forces of production" into the process but also transform themselves by entering into "relations of production" with one another. Furthermore, I reflected on that when the cultural artefacts produced by those no longer invested in maintaining human superiority in culture and politics, it can lead to a significant invention. Digital craft combined with disability potential studied with the argumentative nature of Research through Design (RtD) entails a better understanding of human-centred normative visions of our world. The heterogeneous methodological guidelines in the research execution created a matrix of artistic research, research through design, and social science. The mixed-method innate in qualitative case study co-design prototyping with quantitative data analysis during digital crafting process with meaningful variation in secondary data are presented in the artefacts. The practice-oriented creative skills of digital craft analysed with rigorous science critically address disability beyond identity politics and activism. The material conditions of digital craft are considered to be a process rather than a product, which leads us to realize why design is more than an interface between a material object and its use. The relationships between 'head' and 'hand' + 'materials' + 'tools' manifested themselves in the context critically address the transversal form of non-synthetic understanding of the relational bond that connects us. For various reasons, disability studies and the knowledge of a person with a disability played a significant role in this research, while at the same time, it was essential to acknowledge that the experience of disability is not a minority subject, which a designer should always keep in mind. Unfortunately, we cannot exclude it from the human lifespan; consequently, the dominant idea of a 'normal' human is not a life-long state of being and for some people, it has never been an option. Everyone will be disabled at some point. Disability is not a condition of a minority market (Davis, 1995) because ability as such is continuously changing. While we all go through the process of gaining abilities at an early age, we eventually face losing them as we grow old. A discursive prosthetic design is significant in nature as it is capable of connecting with the general viewer by presenting the argument of the project instead of being a result of a terminal design production as an absolute masterpiece. Design research does not necessarily involve projects that are later realized as market-ready products; in the tangible material reality of the artefact, science and art meet to expand the extent of the boundaries of design problems. Consequently, the public perception of a socially responsible designer should not only be received when a designer plays a vital role in a 'design for care' process. A prosthesis's shape/form/look are not considered for the sake of mere usability or for improving social inclusion, but also for aesthetic purposes. This new kind of aesthetic transmits novel messages embedded in the artefacts, sensitising the society by eliminating the influence of stigma and divergence with the negative perceptions of difference (deviance). To articulate unclear and unimagined possibilities of an emerging reality, the prosthesis artefact does not follow past and recent tendencies of interpreting a corresponding anatomical reference body part. The form of a prosthesis does not need to be based on a bio-normative body model and does not need to be an artificial interpretation of biological limbs. A prosthesis is not necessarily a medical device or an artificial aid either. On the contrary, it can be considered a simple tool. A rigid object as a prosthetic for a long-term attachment to a non-rigid and constantly changing physical aspects of an elbow stump cannot be comfortable. The temporality of body-object interactions in prosthesis design defined by a short-term connection results in a prosthesis that is used only for a specific amount of time with an easy-to-fasten linkage aspect. The temporality of a prosthesis arm can also be affected by the primary function of interaction with another object around. Contrary to technology pushed transhuman tendencies in prosthesis design developments, when technology expands the spatial boundaries of body and object, the prosthesis does not become an integration into-onto the body parts but can be even distantly involved or shortly used. The futuristic transhuman nature of generally favoured prosthetic developments connected to the 'bookish culture', as Buchanan mentioned in connection to repositioning theories, follow the old social expectation of a 'normal' human enhanced with a biosimilar hand.

Due to Luca's congenital malformation, her stable body image contributed to the research. There is a relationship between the structure of embodied knowledge in perceptual awareness to body-centred human norms in society. This investigation demonstrated that the formulation of co-Ability also indicates the relationships between variables in the research, disability and design, disability and society, design and society, prosthetic and society, technology and society, design and art, art and science, humanism and posthumanism. Moreover, the research explored how the theory of co-Ability is more of an active continuum rather than a static product. A collectively distributed subconsciousness in transversal form of non-synthetic understanding of the relational bond that connects us and this shared competence are at the centre of both the ethics and the epistemic structures of continuously morphing network of actions. Co-Ability is a generative and dynamic model that does not represent critical disability studies or social sciences. It is not even an illustration or a justification of a design approach or research. It has built an understanding of the reciprocal representations of conscious and unconscious practice available in everyday life. The epistemic structure of co-Ability critically suggests the possible parallel existence of the dominant human normative convention and posthuman transformations in society. There is a relationship between the structure of embodied knowledge in perceptual awareness and body-centred human norms in society. The two parallel views of human society or moral philosophy were never separated from each other in time. Not only were they categorized into an order of importance, even if their recognition made them disconnected. It indicates that the 'authoritative humanist ideal' and 'the posthuman condition' in society both occur at the same time and had occurred already before the recognition of posthumanist philosophy and that they still play an essential role in each other's existence (Braidotti, 2016; Goodley et al., 2014).

The complex relationships between digital craft practice and academic research were managed during the doctoral research period. As part of the argumentative nature of RtD applied while engaging in the creative practice of the prosthetic co-design process, I analysed it in academic writing and monitored it in educational programs. I was constantly seeking a 'goodness of fit' between artistic aspects and practical executions of numerous identities in teaching activities and in scientific research processes. My involvement in various tasks sometimes represented a contrasting influence (Bennett et al., 2010). The relationships between the roles of a digital maker, a doctoral researcher, and a university educator are

complicated. ‘Particularly problematic is that creative work requires a specific state of mind, and this can rarely be found between staff meetings or lectures’ (Bennett et al., 2010). At the same time, the doctoral research influenced my involvement in developing the preparation materials for a new master program at MOME Design Institute titled ‘Tárgyalkotás’ (Object Creation) with novel art and science curricula on various courses in research through digital and traditional craft practices. The overall goal of the new program is to understand through design and research activities the digital and analogue object-making techniques and other co-technologies, which also disseminate future-focused design approaches, support learning about material manipulation in research developments, and respond to contemporary challenges.

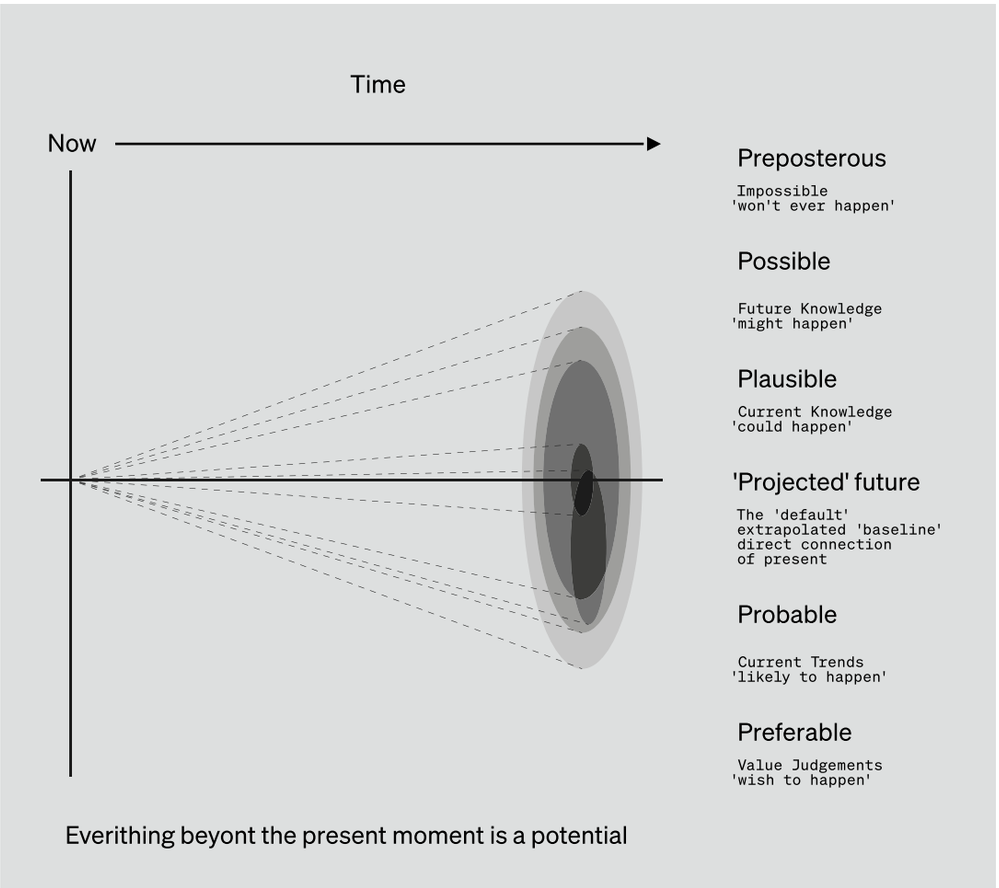


Figure 61: The seven types of alternative futures defined, Joseph Voros 2003

Thanks to the present research, I have developed a deep interest in understanding how science and design interact and finding ways to show what I have explored during the investigation. In the long history of humankind, the parallel development of the products of design and science often serves as a counterpart of the production of knowledge. Instead, there is a simple view of the nature of science that distinguishes it from art, and scientists as much as designers create their theories to guide the developments of their knowledge.

To identify the components of existing structures, RtD tries to shape the components of possible/plausible/probable/preferable structures in situated dialogues (Taylor, 1993; Voros, 2003). It also tries to discover the nature of what operates things and how they are operated in possible structures that do not even exist. RtD is analytical and constructive at the same time and successfully combine thoughts on how things are and how things ought to be. (Simon, 1969). To validate these concerns, the research method does not necessarily need to be repeated, but the artefact could be reproduceable and has an open end to further development for both scientific and terminal product development. ‘The context in which the evidence’ (artefact) ‘is being used is important, as what counts as evidence in one particular context may be unacceptable in another’ (Gray and Malins, 2004). In the present doctoral research, the artefacts are the prothesis prototypes that are reproducible and are open to further developments.

Most commonly, science reinforces different types of design-related disciplines – e.g., material science, engineering science, architectural science, behavioural science with researched scholarly knowledge to build cultural confidence and societal strength. In the intersection of art and science, it has been usefully abbreviated as ArtSci (art-led science) (Miller, 2014). ArtSci’s respective practice in RtD with rigorous and inspired ‘operational consequences’ of design expanded the knowledge over the ‘textbook principle’ (Willem, 1990). As an opposition, SciArt (science-led art) is dominantly a creative practice with the powerful translation of ideas and scientific knowledge into the public. It successfully translates the knowledge embedded in the data science had developed and makes it clear to the public. In these morphological shapes of interaction, the two bodies of characteristics inform and drive the other towards discoveries and new creations.

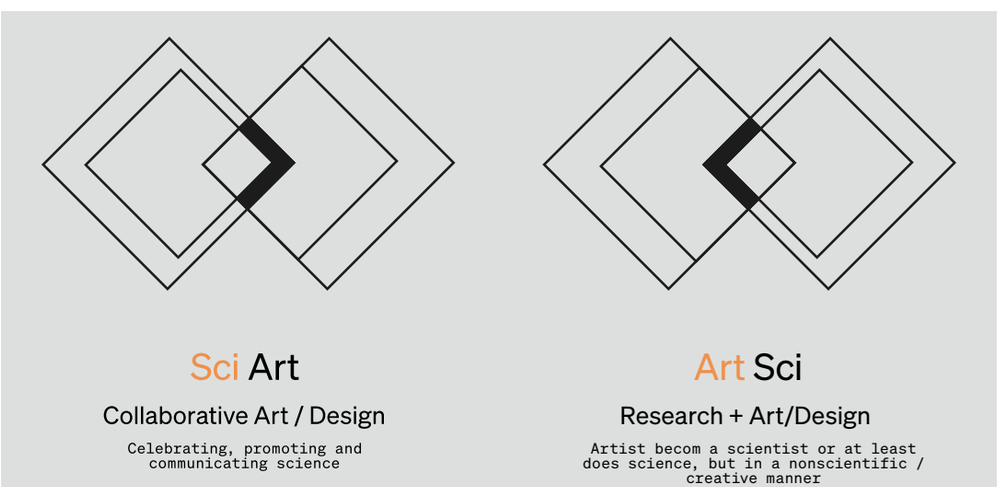


Figure 62: Art and Science relational perspectives

In the case of this doctoral study, I would keep the ArtSci (art-led science) and SciArt (science-led art) abridgement for a non-competitive, explicatory stance towards these two rich fields of discovery. At the oral defence of the dissertation, the textual material side-by-side with the physical materials of the artefact will characterise the knowledge gained in the research. I intend to represent two relational methods that appear in the uniquely installed spaces generated by this research's converging artistic and scientific practice.

Areas of further study

The presented literature review of disability studies led to understanding the controversial and stigmatising aspects of assistive aid and prosthetics. At the same time, technology-pushed and marked-pulled strategies highly support the technological development of prostheses. The question arises: are we the product of these socially embedded situations?

In the case study, only Luca Szabados had the authority to describe her experience of her body, her confidence in herself and her attitude to reality. Her reflections on 'what she needs a prosthetic for' directed the attention to the fact that her disability is congenital, and she learned to live without any aid. As her initial response excluded the need for a prosthetic, the focus shifted to understanding why this was the case. Why does not she like the idea of a prosthetic, and why does I, the designer, tend to care and respect her wish that somehow she does need one? These questions recalled self-reflective dialogues on the subject.

Luca's memories presented her experience in inclusive education in public schools and how she learned to adapt to the environmental demands. She is an outstanding problem solver, and a creative person overcoming the continuous challenges life brings to her (Miller et al., 2004). She doesn't feel like being part of those types of people with disabilities, even if she understands that her visual appearance can categorise her to fit with them. The discursive co-design process with the active contribution of a person with disability resulted in deliberating the importance of self-reflections also on my part as a designer, genuinely examining the unconsciously privileged designer position on social authority and situated engagement. These discussions led me to explore the literature of self-recognition in the framework of the social neuroscience perspective. Based on the studies by Kathleen R. Bogart, 'Current theories of adaptation to disability do not address differences in adaptation to congenital or acquired disability' meanwhile 'a disability is congenital or acquired plays an important role in the development of the disability self-concept' (Bogart, 2014) while posthumanism seeks to 'match the profound transformations we are undergoing. That means that we need to learn to think differently about ourselves' (Braidotti, 2013).

Adaptation to disability is an integral part of the process. It is interconnected with social problems, especially if we consider ability as a continuously changing aspect in our life span (Davis 1995; Dezső 2019). Through the work on earlier previews, my interest has grown in understanding the different distinctions in experiencing self-concept and body recognition for people with congenital and acquired disabilities. I presented a double-blind, peer-reviewed full paper article including a summary of the first articulation of the world co-Ability at the 8th biennial Nordes conference with the theme "Who cares?" at Aalto university in 2019 (Dezső, 2019). The posthuman co-Able perspective developed in the research took me one step further to analyse the two basic body-related self-concepts. Traditionally, the body is considered as a basic instrument, sometimes just a mere mechanical corpse to execute what is in our mind. I became interested in exploring how the structure of embodied knowledge in perceptual awareness is related to body-centred human norms in society. How is the conceptual reflection of the world as we already understand embedded in the human body or the body of any entity?

To explore further, I considered a specific design territory that I know most: combining craftsmanship and digital technologies. I was intrigued by the processes of decentralised soft assembly in which mind, body, and materials act as equal partners in determining co-Abled formations. To start with, my colleagues' traditional craft practice experience and the reflective dialogues on personal experiences at MOME let me reflect on embodied thoughts concerning relationships and the ways of doing. The self-concept was also important by affecting self-efficacy and fulfilment in everyday life situations. My interest was more in understanding self-recognition and the differences in recognising another person or an object. More importantly, the self-based aesthetical difference such as missing lower arm limbs. The matrix of the relational aspects considering another person or ourselves is based on the mental representation of our body, which has two contrasting modalities. One is the structural and quite static, intellectual body image, and the other is the spatial organisation that adapts continuously to the actual situation through sensing it, but it's rarely verbalised. (Dezső, 2019; Vignemont, 2010). The two contrasting accounts of mental representation are comparable with the view of critical disability tendencies in relation to social situations distancing from the concept of understanding disability based on the medical and structurally normative image linked to the human body.

Taking a step back from the depth of the theoretical background in neuropsychology, it is easy to realise that the focus is on the human body and how we experience it, how we experience the world based on the complex comprehension of the human body linked to the roles of culture and politics.

The question is formulated: how are these two opposite views linked in this study could generate further knowledge? The European discourse tends to favour oppositions. It has always bothered me in the traditional understanding of the humanities that the body is seen as the opposite of the spirit. There is an old opposition between matter and mind. Often, the human body or any entity's body is considered a basic instrument, sometimes just a mere mechanical corpse to execute what is in our mind. At the same time, the image of the mind as completely bound with body, world, and action is already visible in Martin Heidegger's Being and Time in 1927 (Bindon, 2018). There is a clear expression mentioned in Maurice Merleau-Ponty's Structure of Behavior 1942 (Merleau-Ponty, 1963).

Recent theories have been progressively converging their emphasis on the high relevance of bodily processes (i.e., the nonconceptual representations and the processing of body-related information) in cognitive processes and self-consciousness, for example, in the works of Bermúdez; Damasio; Gallagher; Varela, Thompson, & Rosch (Bermudez, 1998; Gallagher, 2005, 2005; Varela et al., 1991; Zimmerman, 1996). Indeed, the idea of embodied cognition has gained increasing influence on psychology and neuroscience in recent decades, as Barsalou notes (Barsalou, 2008). Research through Design (RtD) in the First Person Perspective (FPP) would be an excellent method to understand the human thought grounded in self-recognition further in orderto generate critical, new insights to our value system in human-centred societal challenges (Höök et al., 2018; Wilde et al., 2017; Wina et al., 2016). As in his thesis Shusterman argues, the complex and challenging means to be human through the body is an essential and valuable dimension of our humanity. As Richard Shusterman in Thinking Through the Body notes, 'cultivation of skills of enhanced awareness is a central task of somaesthetics' (Shusterman, 2012).

I would suggest areas for further analysis in a larger contextual perspective rather than seeking confirmatory evidence for co-Ability in prosthetic design. Namely, co-Ability's richness in details as a qualitative elaboration supports much possible quantitative research by adding a greater depth of understanding complex social phenomena. To develop and deepen the theory across different cultural contexts, cross-case analyses and learning from various forms of experiences on the identified hypothesis of co-Ability practices could serve for future research. In doing so, the future development could lead to the comparative exploration of the unique competencies of the concept and makes co-Ability act as a common understanding instead of being just a 'buzzword'.

Self-reflection and -criticism are both important components of the presented doctoral study. Strategies for delivering change would involve novel opportunities for interactive exchanges nested within a larger design/research project in discursive design strategy for 'External audience' as 'first-order emphasis' on co-Ability. My research was limited in time and economic resources for further engagement involving public experiences and environments. Using art to aid the public understanding of science recently has shifted to engage the public directly with science through workshops or even open processes. Research with cross-case analysis might provide an empirical background, and a generic question may also arise: what are co-Ability's underlying principles?

The presented discourse in this design research for social innovation combines the situated nature of design and the criticality of digital craftsmanship with the social situation of disability within the framework of reforming the view of our everyday lives and culture. Not withstanding, if we offer such changes to reshape the relation between the 'human' and the material reality of our surroundings, it could be highly beneficial to the academy in the long run.

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Zimmerman, J., Forlizzi, J., 2014. Research Through Design in HCI, in: Olson, J.S., Kellogg, W.A. (Eds.), Ways of Knowing in HCI. Springer, New York, NY, pp. 167–189. https://doi.org/10.1007/978-1-4939-0378-8_8
Zimmerman, J., Forlizzi, J., Evenson, S., 2007. Research Through Design As a Method for Interaction Design Research in HCI, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI ’07. ACM, New York, NY, USA, pp. 493–502. https://doi.org/10.1145/1240624.1240704
Zimmerman, J., Stolterman, E., Forlizzi, J., 2010. An Analysis and Critique of Research through Design: towards a formalization of a research approach, in: DIS 2010 - Proceedings of the 8th ACM Conference on Designing Interactive Systems. Presented at the DIS 2010 - Proceedings of the 8th ACM Conference on Designing Interactive Systems, Aarhus, Denmark, pp. 310–319. https://doi.org/10.1145/1858171.1858228

List of figures

Curriculum vitae

Academic records
2016 - 2021

2020 Journal article: Co-designing for inclusion in international/ interdisciplinary teams, International Journal of Education Through Art, Band 16, Nummer 2, 1. Juni 2020, S. 177-196 (20) Publisher: Intellect, DOI: https://doi.org/10.1386/eta_00025_1

2019 Guest Lecture (En) at Universität für Angewandte Kunst Wien, title: "Critical Theory throughout Design, Art+Science and Disability Studies" (https://www.dieangewandte.at/aktuell/aktuell_detail?artikel_id=1573733271634)

2019 Book article (H) 'A gondoskodó tervezés és gyakorlati reflexiók'. In eltereader.hu, (Budapest, Hungary: ELTE Bárczi Gusztáv Gyógypedagógiai Kar), pp. 154–166. ISBN:9789637155888 (http://www.eltereader.hu/media/2019/11/Szabalyta-lan_konturok_2019.pdf)

2019 Book article (H) "Co-design – Oktatási programsorozat a gondoskodó tervezés jegyében." In EGYÜTT OKTATUNK ÉS KUTATUNK! INKLUZÍV MEGKÖZELÍTÉS A FELSŐOKTATÁSBAN, Budapest: Bárczi Gusztáv Gyógypedagógiai Kar, 195–205. (http://www.eltereader.hu/kiadvanyok/katona-vanda-cserti-szauer-csilla-sandor-anikoszerk-egyutt-oktatunk-es-kutatunk/)

2019 Full Paper presentation (En) at 8th biannual Nordic Design Research Society (Nordes) conference at Aalto University, Finland (https://archive.nordes.org/index.php/n13/article/view/463/434)

2019 Speaker (En) at Design Culture & Somaesthetics Conference Budapest /Hosted by: MOME Doctoral School Design Culture Studies Doctoral Program and the Hungarian Forum of Somaesthetics (https://doktori.mome.hu/conference2019/program/)

2019 Speaker (En) Fifteenth International Conference on Technology, Knowledge & Society CosmoCaixa Barcelona, Spain

2019 Speaker (En) Thirteenth International Conference on Design Principles & Practices at St. Petersburg University, Mikhailovskaya Dacha Campus

2018 Invited moderator (H) at the 6th Disability Studies Conference "DIVERSITY AS A SOCIAL VALUE?" at the ELTE Eötvös Loránd University, Budapest

2018 Speaker (En) at D'Art: Teaching Artistic Research Conference, Vienna Solo presentation at Session 3: Hybrid Pedagogies: Teaching for Interdisciplinarity
Group presentation with Ruth MATEUS-BERR ao. Univ.-Prof. Mag. art. Dr. phil. University of Applied Arts Vienna, Stephan Trimmel, László Lukács, Julijana Rosoklija, Gabriela Urrutia Reyes, Hanna-Christina Mannsberger

2018 Speaker (En) at CFP International Conference, Somaesthetics: Between the Human Body and Beyond, Szeged, Hungary

2017 Speaker (H) at the 5th Disability Studies Conference at the Eötvös Loránd University in the framework of the 14th Festival of Hungarian Science, sponsored by the Hungarian Academy of Sciences alongside seven Fulbright alumni presenters. ISBN 978-963-7155-72-7

Fellowships and awards
2016-2021

2020 EDF AND ORACLE AWARD FOR A SCHOLARSHIP TO RESEARCHER WITH DISABILITY (http://www.edf-feph.org/newsroom/news/announcement-edf-and-oracle-award-scholarship-researcher-disability)

2019-2020 New National Excellence Program Scholarship (ÚNKP)

2019-2020 Die Aktion Österreich-Ungarn, Wissenschafts- und Erziehungskooperation 101öu14 Knowledge Sharing Programm im Zeichen von co-Ability Research Founding

2019 Emerging Scholar Award from Common Ground Research Network at Fifteenth International Conference on Technology, Knowledge & Society (https://techandsoc.com/about/history/2019-conference)

2018-2019 New National Excellence Program Scholarship (ÚNKP)

2019 Campus Mundi scholarship for outgoing students, short-term doctoral research, Thirteenth International Conference on Design Principles & Practices, St. Petersburg

2019 Campus Mundi scholarship for outgoing students, short-term doctoral research, Fifteenth International Conference on Technology, Knowledge & Society, Barcelona

2016-2020 Doctoral government fellowship

2017-2018 Grant of National Cultural Fund of Hungary (NKA) at MOME | managing organizer of knowledge Sharing Exchange Program between MOME and the University of Applied Arts Vienna

2018 Grant of National Cultural Fund of Hungary (NKA) for 3D printing activities

2018-2019 Grant of National Cultural Fund of Hungary (NKA) at MOME, managing organizer of an international exchange program between MOME and KU Leuven University ANTHROPOLOGY OF DISABILITY RESEARCH LINE

Teaching activites 2016-2021

2020 DesignFiction Workshop MOME Design Institute and MOME Theoretical Studies Institute, Co-Lecturer with: Jozsef Tillmann, Akos Schneider, Zsolt Miklosvölgyi, Villo Turcsany, Edit Blaumann
2020 Masters supervision James Carcass FUTUREFACE (http://www.jamescarcass.com/)
2020 Clay 3D printing MOME Digital Lab workshop (http://renatadezso.com/?portfolio=clay-3dprinting-university-workshop)
2019 Co-Lecturer and course coordinator – interdisciplinary and international cooperation with MOME and the University of Applied Arts Vienna.
2019 Lecturer, course coordinator–“data physicalization” or “physical visualization” Digital Crafting at MOME Digital Lab | 3D scanning, Mesh Modelling + 3D printing, MOME, Budapest
2018 Co-Lecturer with Andras Mohacsi Dla Habil. – Space experiences program, MOME, Budapest
2018 Lecturer and course coordinator – Microworld Structures | 3D printing and research, MOME, Budapest
2018 Masters supervision Annabori Lanyi PlayBALL
2018 Co-Lecturer and course coordinator – Knowledge Sharing Exchange Program between MOME and the University of Applied Arts Vienna. Invited Lecturers: Fanni Csernatony, Ruth MATEUS-BERR ao. Univ.-Prof. Mag. Art. Dr. Phil. University of Applied Arts Vienna
2017 Co-Lecturer and course coordinator with Fanni Csernatony and Balint Veres PhD Habil. Managing director at MOME Doctoral School – ‘Design For Care’ course, MOME, Budapest + Hack for Care workshop with Fanni Csernatony
2017 Lecturer, course coordinator –- 3D modelling, MOME, Budapest
2016 Lecturer- 2D modelling, laser cutting through mask making, MOME, Budapest

Review contribution

2019 peer-reviewing two articles for the Design Education Forum of Southern Africa, DEFSA conference proceedings. http://www.defsa.org.za/

Mobility, workshop, summerschool

2021 Practitioner at EU Craft Hub: Maker Exchange Residencies virtual residency program (https://www.crafthub.eu/#about)
2021 Erasmus+ mobility, visit GLASS SYMPOSIUM ANNÍN
2020 NORDES Summer School 2020 / COLLECTIVES. Designing beyond the individual (https://nordes.org/summer_school.html)
2020 RtD in Situ: Discussing the Domains and Impact of Design Research in conjunction with DIS 2020
2020 DIS conference, Designing for the End of Life of IoT Objects, the University of Edinburgh, United Kingdom (https://sites.google.com/view/endoflifeiot/accepted-submissions) Submitted work title: Translational symmetry and contrasting account in abilities between IoT device and its user?
2019 Erasmus+ mobility for proposal preparation workshop for European cooperation in science and technology at ELISAVA Barcelona
2019 Erasmus+ mobility for Consortium Meeting Agenda Innovative Training Networks (ITN) MARIE Skłodowska-CURIE ACTIONS founding proposal at KU Leuven.
2017 Becoming Disabled: A performative workshop and installation | Camino Events, Research Pavilion, Venice 30.6.-1.7.2017 | organizers: Liisa Jaakonaho & Kristina Junttila
2003-2009 Work Experiences, living in Torino, Italy

Exhibitions 2016-2021

2020 International Online Group Exhibition co-Ability Design Practises, Matter and Mind in Disability, Austrian Cultural Forum Budapest, H
2018 Tallinn DesignWeek Digital Crafting: MOME Transfer Lab International Group Exhibition
2012 International Group Exhibition, Schmuck DE. Munich, What is in frame? | Gisbert Sach and Lőrincz Réka (contemporary jewelry) Dezső Renáta (3D projection mapping)
2012 Group Exhibition 2012, 10 contemporary jewellery artist + 10 visual artists = 10 objects at Filter Gallery | projection mapping on Réka Lőrincz contemporary objects
2011 International Group Exhibition / Video mapping with Bordos Artworks Videomapping the Republic Square in Yerevan at Armenia's Independence Day, Videomapping the Art Museum of Timisoara
2011 Group Exhibition 2011, 3D video installation, Sterling gallery' LIGHT' Krisztián Ádám jewellery artist Renáta Dezső video installation
2011 International Exhibition, VLS Video Mapping Trophy Paris Heavent Centrum / final show