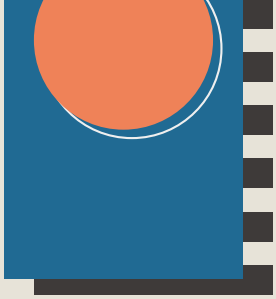

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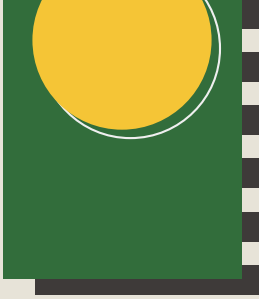

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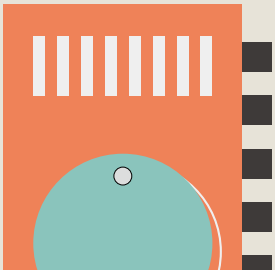
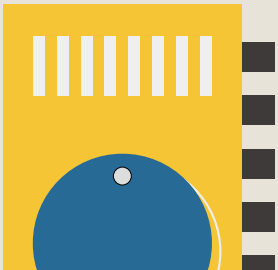
Exploring Intelligent Technology for Older People through Speculative Design

Master Thesis

Yu Huang





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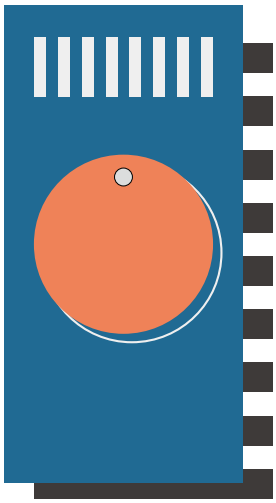

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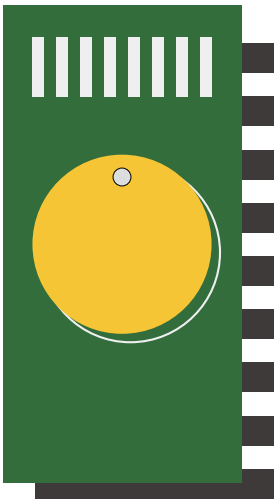

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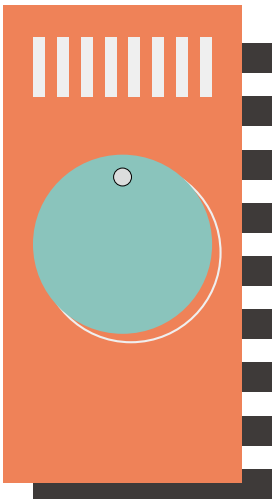

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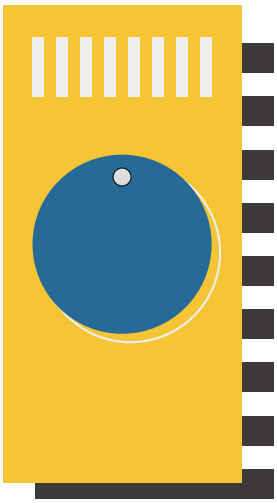

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Executiev Summary

This report first discusses the phenomenon of aging, how it is commonly understood, and the state-of-the-art of the technology for aging people (gerontechnology) (chapter 1). In the analysis, the author briefly describes the origin and development of the notion of aging through medical, social, and cultural lenses. How the negative narrative around aging has hamstrung the innovation for older people is presented by enumerating three types of design pitfalls identified in today's mainstream gerontechnology. Drawing on a body of literature (e.g. the 'successful aging model' and the 'personhood turn' in the 'care model') and projects, the author shows new voices attempting to overturn this negative narrative. The Capability Approach (CA), especially Nussbaum's capability theory which provides a concrete and substantive normative foundation for probing into older people's lives is introduced (chapter 3 prologue). Interviews are conducted to obtain in-depth understanding of people's needs, wants, and challenges (chapter 3). Based on the literature research and empirical studies, a gap between the real needs and wants emerging in the aging process and what is provided by current mainstream gerontechnology is identified (tension 1) (chapter 4).

Informed by several inspiring design frameworks or theories (e.g. design for appropriation, end-user development, ambiguity in design, meta-design), the author proposed design for openness as a potential design strategy to address the first tension (chapter 5 prologue). What is so powerful about 'openness' in design is its potential to satiate various needs over time, in the meanwhile, promote autonomy in users. A theoretical model is theorized to provide firm design handles (chapter 5 prologue). Next, co-speculation sessions are conducted to gather situated knowledge and to experiment with the idea of design for openness (chapter 5). Findings from the sessions reveal the potential risk of leaving the design completely open: ineffective appropriation caused by misalignment between use and design (chapter 5). How to lower the seemingly paradoxical misalignment between design and use while still maintain the openness in design becomes the focus of the rest this research (tension 2) (chapter 5).

A concept artifact is crafted as an explorative attempt to address the misalignment between use and design (chapter 6). Next, the evaluation of the concept artifact is conducted which results in rich design implications (chapter 7). Insights from the evaluation sessions also help further develop the theoretical model (chapter 8). An alternative design process that's different from the traditional one is put forward and limitations are discussed and directions for future research are sketched out (chapter 8). The report closes by reflecting on the whole project and summarizing the main contributions of this project (chapter 9).

Reading Guide

How to read this report

This part will show readers the layout of this report which structured the content. You can see the structure of the whole report on the right page.

Each chapter begins with a brief introduction to the main topic discussed afterwards. Then research and design activities are elaborated in the main text. An overview of main takeaways from the chapter will be summarised in a closing section with a dark background (Figure 1). These provide the most useful findings in that chapter which can also be used to grasp the gist of the report in case of lack of time for closely reading the full report.

The general content of each chapter can be seen on the right.

> ***Theories, Quotes, and Examples***
>
> *Elaboration of related theories, illustrative quotes and examples are in italic and sometimes on a beige background (Figure 2).*

Figure 2 An example of a section containing quotes

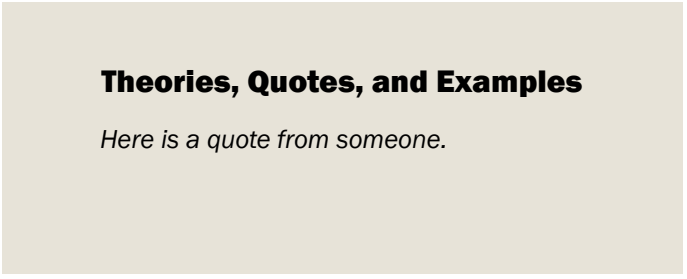
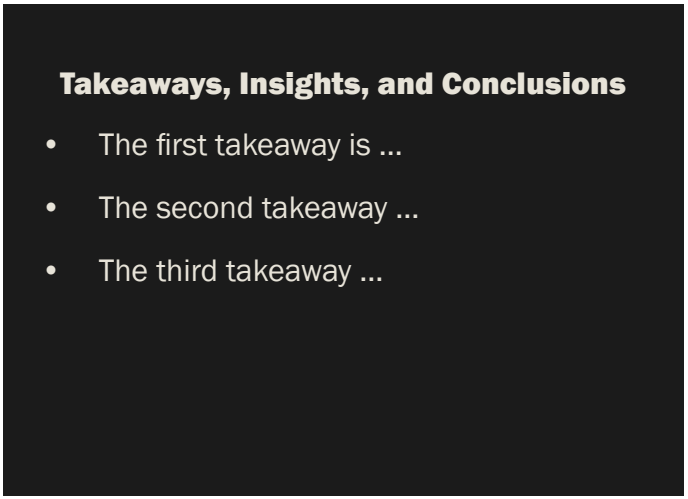


Figure 1 An example of a section containing takeaways



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Introduction

PROJECT BACKGROUND

This section briefly describes the main topics which are touched upon in this project.

Aging Society

The growth of the aging population is happening worldwide. According to the statistics of OECD, the percentage of the elderly population worldwide has reached 17.46% in 2020 and the number in the Netherlands is even higher at 19.64% (Figure 3). The numbers are predicted to increase in the following years. While demographic aging can be seen as a success in health care and social care, it also brings challenges for governments in terms of increasing healthcare budgets and pension schemes.

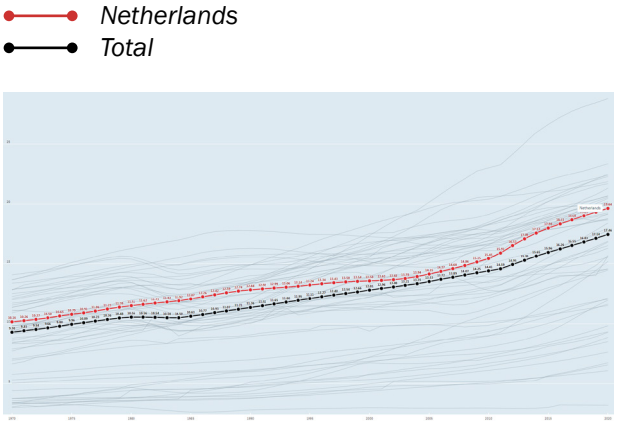


Figure 3 Percentage(%) of elderly population, 1970 – 2020. (Source: https://data.oecd.org/pop/elderly-population.htm)

Aging in Place

According to the research results by the American Association of Retired Persons, most seniors prefer to age in place, which is living in their own residence rather than in an institution or care center (AARP, 2021). Values of aging-in-place can be a potential cost saving compared with entering a nursing home (Rantz et al., 2015). One study conducted in the United Kingdom indicates that the home provides the person with a sense of security, comfort, and a sense of control over one's life (Sixsmith, 2008). Furthermore, aging-in-place also plays a critical role in the quality of life which positively contributes to a sense of identity through autonomy and independence and is an important component of social connection (Wiles et al., 2012). On the other hand, there are risks

in remaining at home revealed by research from the Enable-Age project (Iwarsson et al., 2007). For example, not every house is suitable for aging-in-place and poor housing condition renders aging-in-place even detrimental to aging people's well-being and quality of life (Tinker, 1997). Even though home modification plays an important role in facilitating aging-in-place (Hwang, 2011), some households might be difficult to modify or not suit for adjustments that can meet the needs to age well in place, which again makes home not the best place for aging. Many factors might influence the aging-in-place process (Ball et al., 2004), which confirms that remaining at home doesn't always ensure an independent and high quality of life. Extensive analysis and deep understanding of those factors need to be taken into account to achieve truly aging well in place.

Gerontechnology

The success of aging-in-place will require substantial innovation in the incorporation of advanced technologies, behavioral science, community design, and policy (Kim et al., 2017). Pramod well summarized the assistive technologies for the aging such as the Internet of things (IoT), Information and Communication Technology (ICT), smart wearable technology, Augmented/Virtual Reality(AR/VR), Ambient/ Active Assisted Living (AAL) robots, and so on (Pramod, 2022). They have already been applied to cope with different users' needs including social isolation, functional decline, cognitive disorders, and so on (Piau et al., 2014). Even though technology has been proved to have the potential to enable aging people to age in place, the effectiveness of those technological solutions is not guaranteed. In the pre-implementation phase, the acceptance of technology for aging in place are influenced by various factors such as concerns regarding technology (e.g., high cost, privacy implications, and usability factors), etc. (Peek et al., 2014). Besides, the fact that minimal evidence shows that smart homes and home health monitoring technologies help address disability prediction and health-related quality of life, or fall prevention (Liu et al., 2016) seems to shatter the promising potential of technology in addressing those challenges. Therefore, a deeper understanding of the relationship between technology and humans, in particular, aging people in this project is urgently needed.

PROJECT OVERVIEW

This section describes an overview of the project including the scope, used approaches, process, and outcomes.

Project Scope

The research landscape, which consists of aging and technology, has been unfolded in the previous section, and thereof the research topic is identified in the intersection of aging-in-place and technology (Figure 4). This project aims to use technology to address the challenges confronted by aging people while aging in place. It is identified as a “wicked problem” in which the stakeholders might have conflicting values.

With this, preliminary research questions are formulated to navigate the process of exploration in the fuzzy front end (Sander & Stapper, 2012) of this project before defining what are the most relevant problems to be solved.

RQ1: (Understanding Aging) What do aging people need to achieve successful aging-in-place?

RQ2: (Understanding Gerontechnology) How can technology support aging people in this process? What are the deficiencies and limitations of current technologies?

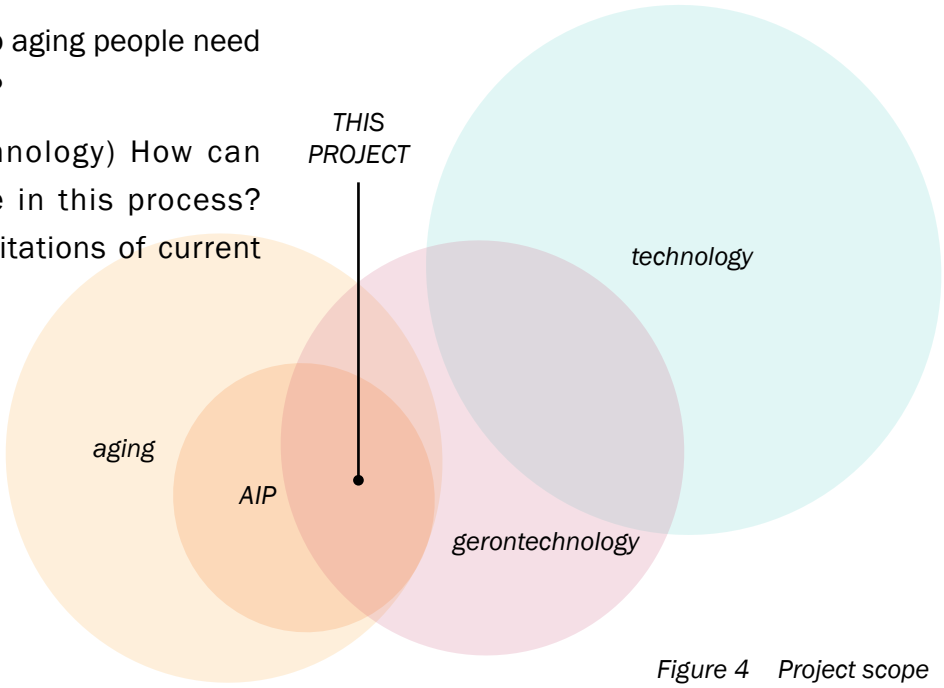


Figure 4 Project scope

Approach

Research-through-Design (RtD)

This project follows a Research-through-Design (RtD) process. This approach was first put forward by Frayling (1993) in Research in art and design. It is about "making the right thing" (Zimmerman et al. 2007) by synthesizing the knowledge produced by the upfront researchers and conveying the insights to the community of practitioners. Since this project is identified as a "wicked problem", RtD suits quite well by using the design process of ideating, iterating and evaluating in order to establish a concrete problem framing and articulate what should be the preferred state. A series of artifacts—models, prototypes, products, and documentation produced along with the design process brings design knowledge from the research community to the practice community. This might also come with a theoretical framework crystalizing and articulating the design knowledge.

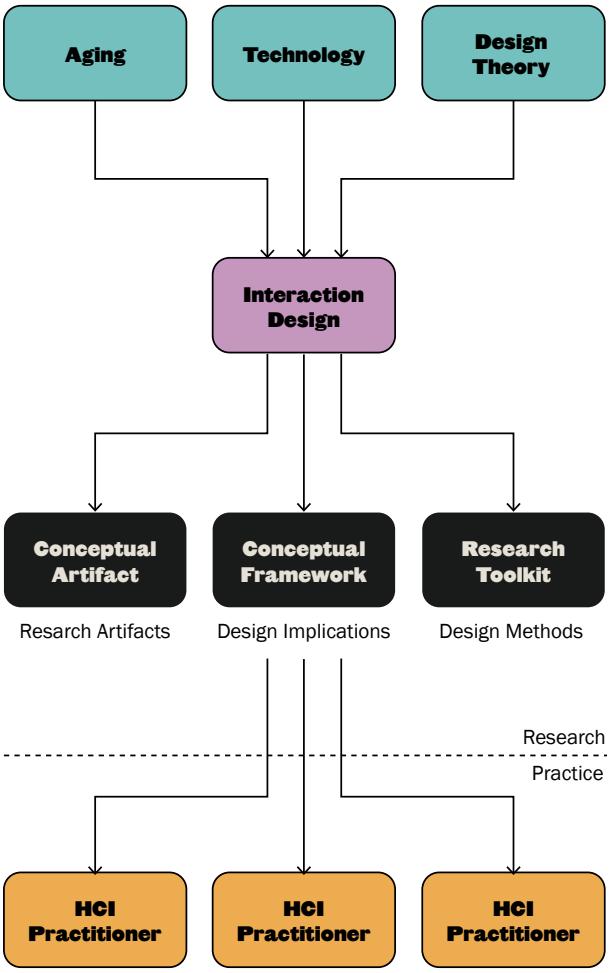


Figure 5 A model the RtD in HCI adapted from Zimmerman et al. (2007)

To sum up, the reasons this project took the RtD approach are the following.

- **Knowledge Generation**

  The proceeding of this open-ended project demands a learning-by-doing method to acquire knowledge generated through design activities (Stappers and Giaccardi, 2017, p.12);

- **Stakeholder Involvement**

  To deeply engage aging people requires the prototype used in the RtD method that can serve as "a research archetype" that embodies the hypothesis for validation and further iteration;

- **Exploitation of Researcher's Skillset**

  Research-through-Design can make most of the design skills of a designer as a researcher to facilitate design research work.

In particular, speculative as a form of Research through Design has been deployed in this project. To be more specific, speculative approaches were utilized mainly for 1) generative purposes: co-speculation sessions were conducted with the target group to engage participants in future conversations to better understand their needs and preferred ways to satiate their needs through imaginative activities; 2) provocative purposes: the speculative design was undertaken to craft a concept artifact that embodies the intermediate knowledge for further theoretical advancement and open up a discursive space to experiment with creating alternative relations between humans and artifacts.

Figure 6 the researcher in this projet doing an interview

Design with Older People

It has been recognized that crucial elements of successful implementation of technology for aging in place are prioritizing the needs and wishes of aging people, acceptance of potential users, perceived benefits of the technology, and favorable preconditions for its adoption by aging people (Peek et al., 2016), but this is often difficult to achieve without involving aging people in the design process. Hence, this project keeps target stakeholders in the loop and strives to design with and for aging people.

To sum up, aging people are involved in the following phases:

- **Research phase**

  One-on-one interviews were conducted to personally know the aging participants

- **Ideation phase**

  Co-speculative sessions are conducted to co-create with aging people

- **Evaluation phase**

  Feedback sessions are conducted by using speculative design artifacts to collect feedback from aging people.

Process Overview

The schematic diagram on the next two pages shows the overview structure of this project. It can be roughly divided into three phases.

Phase 1

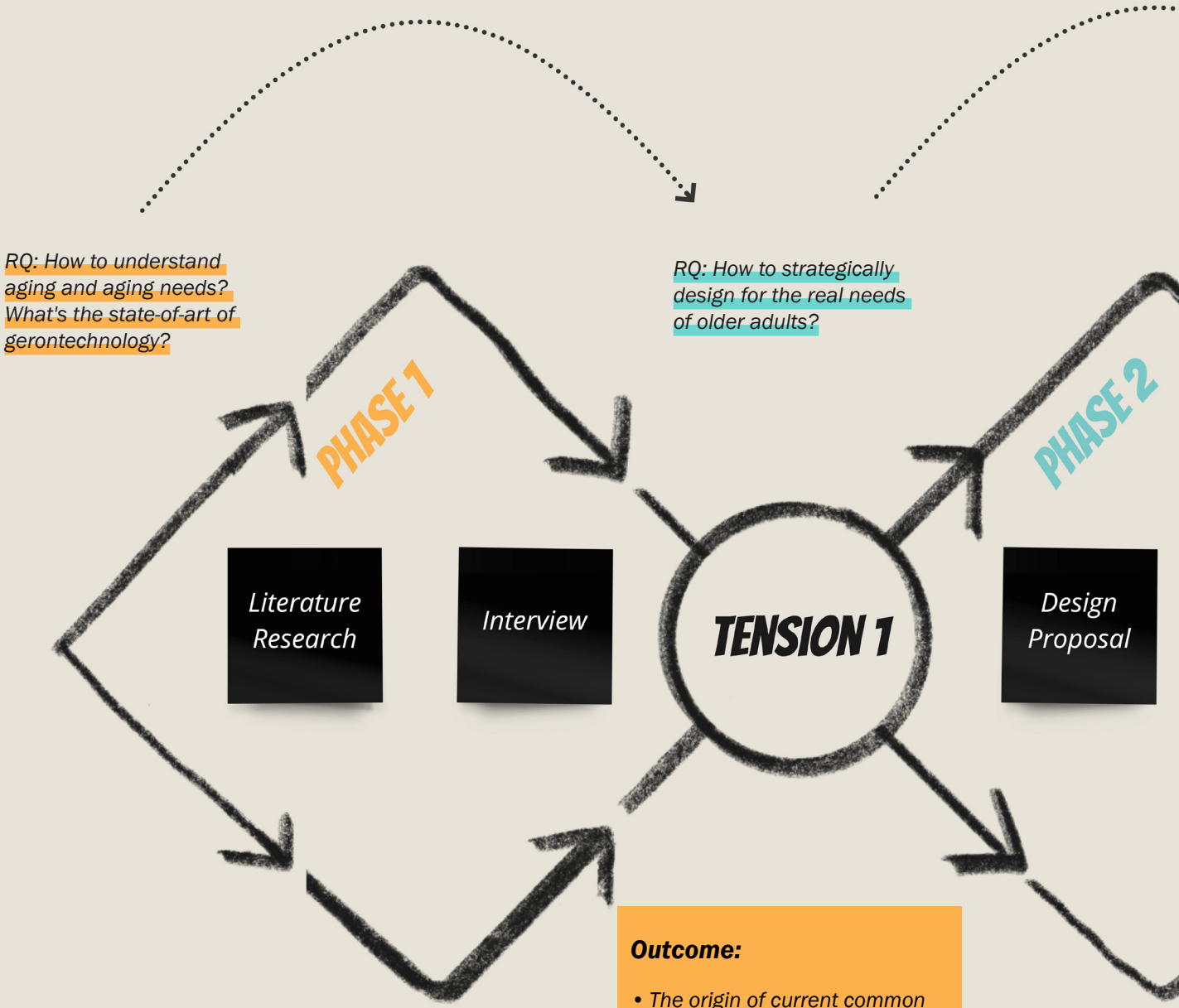
Starting with research into the notion of aging and the state-of-art of mainstream gerontechnology, I sought to challenge the current common understanding of aging and identified the pitfalls of mainstream gerontechnology up to date. This surfaced the mismatch between the real aging process and technology design. I closed the first phase with the establishment of the design goal and the formulation of the design vision.

Phase 2

To address the tension identified in the previous phase, I proposed 'design for openness' as a potential design strategy. Based on the study of related theories, I also theorized an intra-action model which served as the theoretical base of the co-speculation sessions with older participants. In the following, the sessions with older participants revealed the potential risk of leaving design completely open —- that is the second tension —- the ineffective appropriation caused by a misalignment between use and design. How to avoid the risk became the focus of the research in the next phase.

Phase 3

Further exploration in coping with the misalignment was done through the conceptualization of a concept artifact. Evaluation of the artifact offered rich design implications and drove the development of the intra-action model. An alternative design process was proposed in addition to the theoretical framework. I wrapped up this phase with critical reflections on the design process and recommendations for future research.



Outcome:

- *The origin of current common understanding of aging*
- *The pitfalls of mainstrean gerontechnology*
- *Related theories against the negative narrative around aging*
- *Reconception of aging*

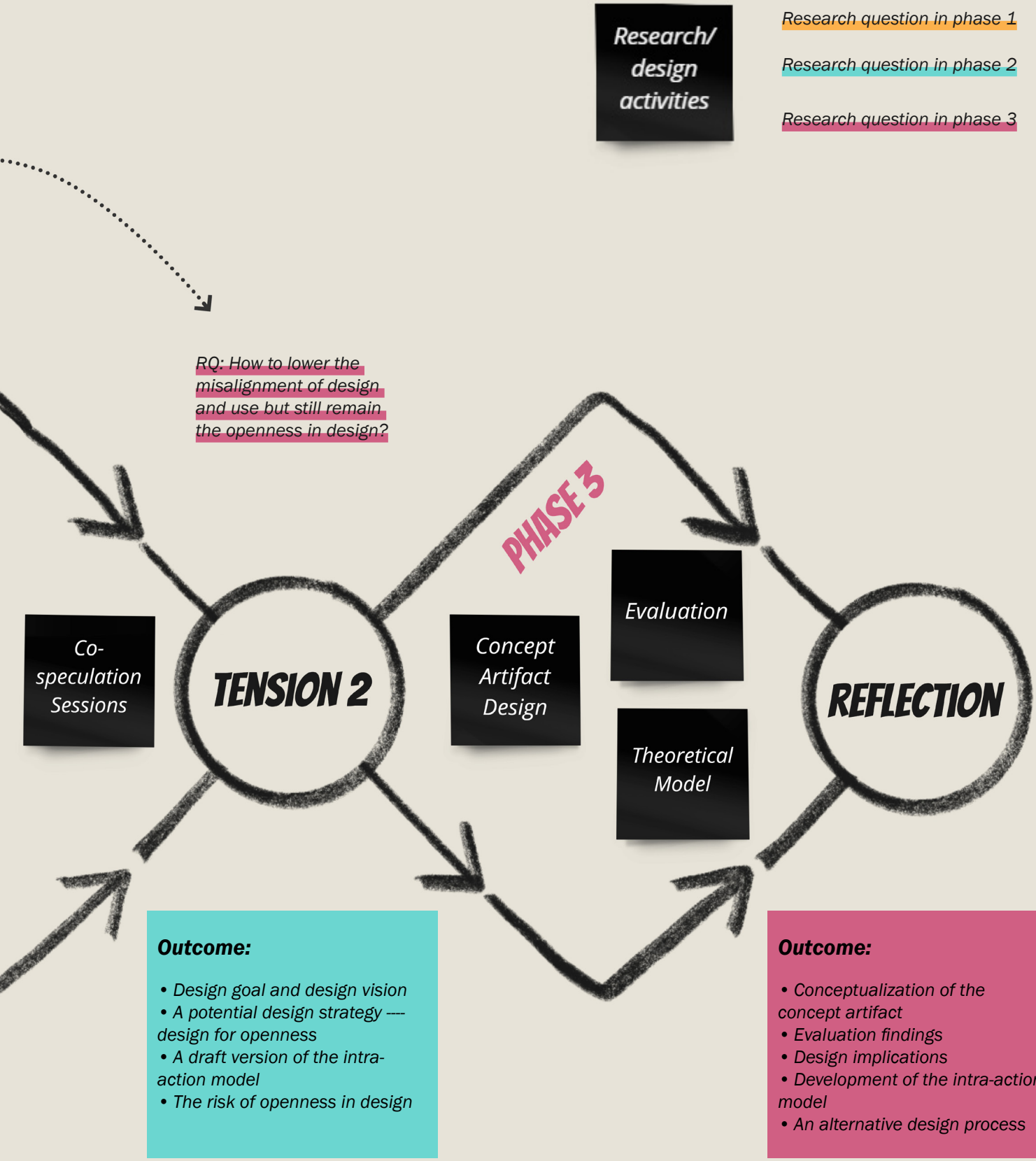


Figure 7 Project Process Overview

Main Contributions

The main contributions of this project are trifold including empirical findings, methods, and design.

Empirical Findings

The mismatch between the needs in the aging process and what's provided by current mainstream gerontechnology.

The literature research on the origin of today's notion of aging indicates that our common understanding of aging is far from an objective concept but heavily influenced by early medical findings, problematized by societal and governmental administrations, and fixated by cultural stereotypes. Three pitfalls were summarized after analysis of current mainstream gerontechnology, which are ignorance of aging people's needs, misunderstanding of aging people's needs credited to medicalized and simplified view of aging, and over-emphasis on aging people's needs distorted by the problematized view of aging. Interviews conducted with older participants (N=5) confirmed the findings from the literature research and generalized the characteristics of the aging process which is developmental, multi-faceted, dynamic, complex, and personal. It is in sharp contrast with mainstream gerontechnology which is rigid, over-medicalized, one-size-fits-all, stigmatized, or tech-oriented. This boils down to the mismatch between the needs in the aging process and what's provided by current mainstream gerontechnology (Figure 8).

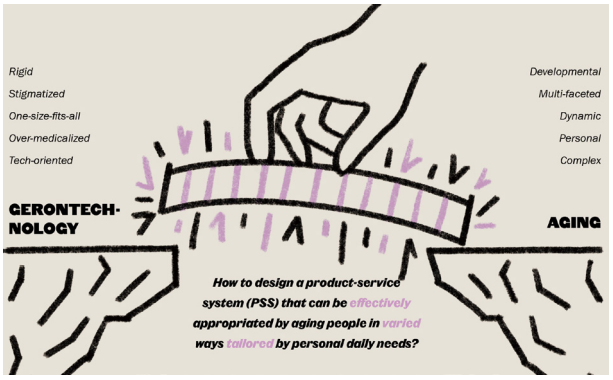


Figure 8 The mismatch

The proposal of 'design for openness' as a design strategy.

In recent years, the concept of performativity has influenced the design field. The performative approach prompts a relational view toward the interaction between humans and technological objects. The performative discourse later converges into several practical design proposals that embrace and encourage the continuous co-constituting entanglement relationship between humans and technological objects. This line focuses

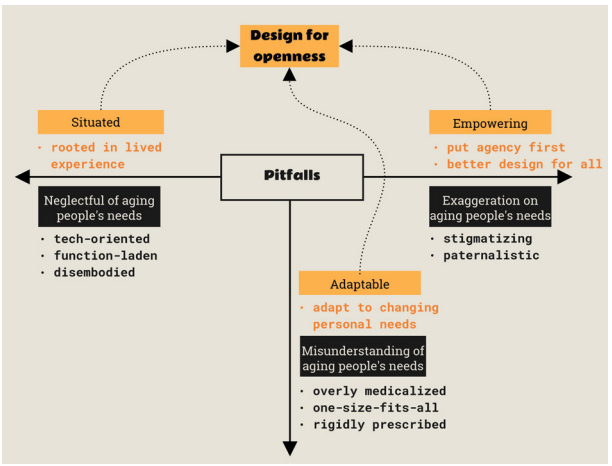


Figure 9 Design for openness as a design strategy

on concepts such as appropriation, ambiguity in design, meta-design, end-user development, and so on. Inspired by those design theories, I proposed a potential design strategy named ‘design for openness’ which can bring the advantages of situatedness, dynamics, and autonomy (Figure 9).

The potential risk of openness in design.

Co-speculation sessions were conducted to experiment with how to implement ‘design for openness’ in practice. The findings from the sessions revealed the potential risk of leaving the design completely open: ineffective appropriation which includes inefficient use and failure of adoption. After analysis, the root cause of ineffective appropriation was identified to be the misalignment between design and use.

Conceptual Construct

Magic Intra-action Model

Based on the study of related design theories following the strand of performativity, I theorized a conceptual framework — the magic intra-action model — to ground the intra-action process. The three components in the model, deriving from both the human side (desired capabilities) and the thing side (physical affordances and digital functions), provide firm design handles for practitioners (Figure 10).

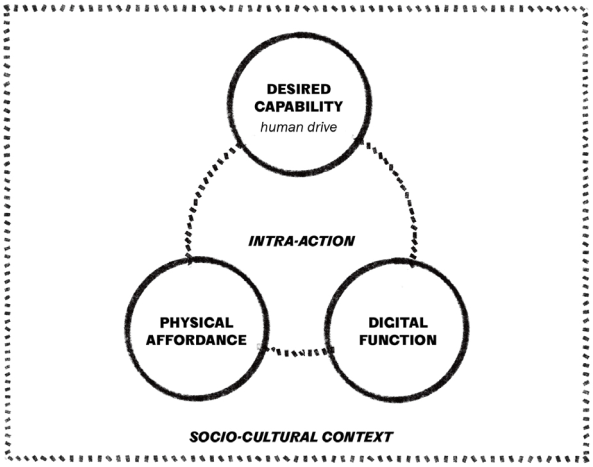


Figure 10 Magic Intra-action Model

An Alternative Design Process

At the end of the exploration phase, I proposed an alternative design process driven by association (Figure 11). It is a profound and promising direction that’s worth further research. This design process is different from the traditional problem-solving design process. Though there are still risks and limitations in this design process, it works well to break design fixations and generate ideas for ludic design.

Concept Artifact

A concept artifact was conceptualized to embody

the conceptual constructs (Figure 12). During the exploration, the development of the concept artifact and the theoretical framework ran in parallel and stimulated and complemented each other. Together with the theoretical framework, the concept artifacts also consist of an important part of the research results.

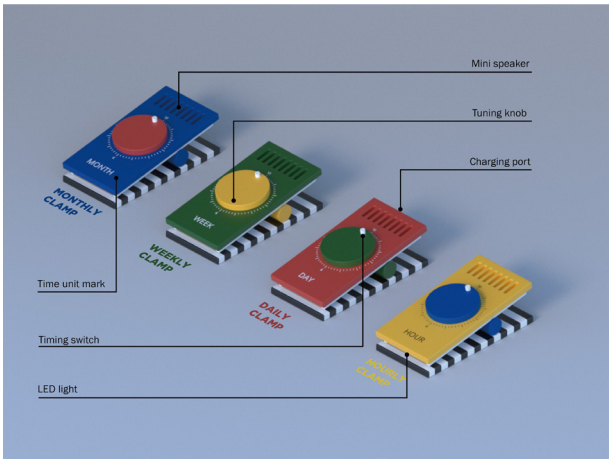


Figure 11 Concept artifact design

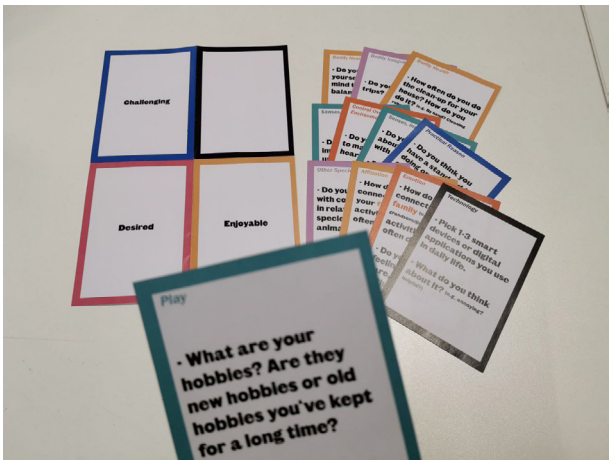


Figure 12 A probing toolkit

Methods

A probing toolkit based on the Capability Approach.

I extensively utilized Nussbaum's capability theory to develop question categories and specific guiding questions around the central capabilities. This resulted in a card set serving as a probing toolkit to investigate older people's lives in a comprehensive way (Figure 13). I used the toolkit to stimulate conversation with the participants. The toolkit provides the means to put abstract philosophical theories into practice. It also stands as an example exhibiting how to translate abstract theories into a practical toolkit for practitioners.

An assessment framework inspired by the Capability Approach.

In the evaluation phase and the development of the alternative design process (i.e., association-driven design process), I drew on many concepts in the Capability Approach such as conversion factors and the list of central capabilities put forward by Nussbaum. To be more specific, I analyzed the mentioned use scenarios in the evaluation sessions by classifying them by the category of capabilities. This helped me clearly demonstrate the resulting expansion of capabilities enabled by the technological artifact. Besides, the conversion factors are crucial to transforming potential assets (in this case, technological artifacts) into capabilities. This concept serves as a reminder of taking the environment and inherent capacities of different individuals into account in design practices.

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Misconceptions

MISCONCEPTIONS

A Review of the Concept of Aging

What are we talking about when we are talking about aging? How did we come to today's conventional definition of the aged? Instead of accepting today's notion of the aged as it is, this part attempts to trace back the current understanding of the aged and examine the origins via lenses of medical science, society, and culture (Figure 13).

Biology-rooted: Medicalisation of Aging

In the 1800s, the idea that aging was tantamount to the loss of 'vital force' prevailed. And it was believed that the waning of vital force made people 'predisposing debility' (Long 1962), thereby susceptible to diseases. Doctors began to treat people over certain ages differently from younger people because of the resistance to the medical intervention of older bodies. Though the development of the medical field would eventually disprove the medical vital-force theory it still left an indelible mark on today's narrative of old age - the medical and biological view of aging still dominates the modern understanding of aging. Indeed, medical and technological advancements prolonged our life expectancy to a great extent in comparison to the past. In the meantime, human perception of aging is irreversibly altered by technological innovation which contributes to the deferral of death. This deferral constitutes the contemporary imaginary of aging (Bishop 2019) and brings the unrealistic desire for immortality that transforms the natural process of aging into a challenge to be conquered. This might reinforce the equation of aging with a process of physical and biological deterioration and lead to the problematized view of old people and old age (Estes et al. 1984), which will be elaborated on in the following.

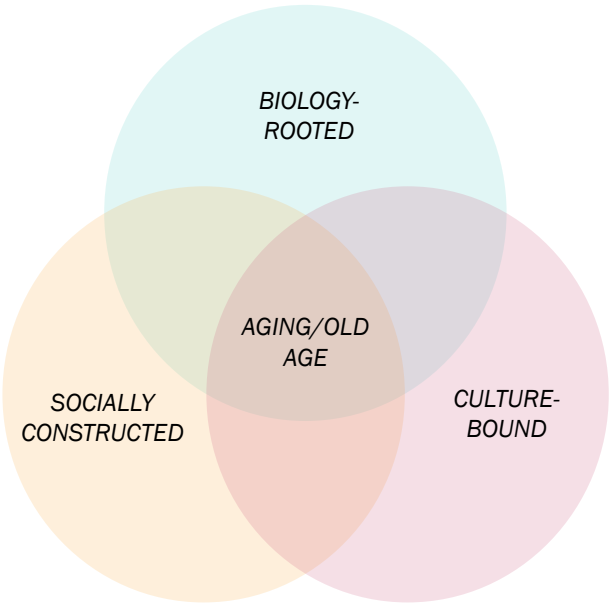


Figure 13 the notion of aging/old age

Socially Constructed: Problematisation of Aging

From the perspective of the older, the equating of aging with decrepitude was once beneficial in terms of some government programs it led to in the last century. Admittedly, if it were not for the medical vital-force theory, there would not have been the advent of the first pension plans, nursing homes, and other institutions aimed to help older people. On the other hand, it turned aging into a problem to be solved on a mass scale. Old age is treated as intrinsically debilitating and 'the notion of a healthy old age was erased in this mode of discourse', as written by critical gerontologist Bryan Green (1993). In recent years, it is not rare to come across negative rhetorics around demographic aging in the news, articles, or even academic papers, such as "the approaching storm", "silver tsunami", "age time bomb", "avalanche" and so on, connoting an unsustainable economic burden on care services (Mort et al. 2013). Those problematic ways of framing result in defining aging people themselves as problems that need to be solved.

According to historical research, before the second half of the 19th century, aging was understood on an individual and flexible basis - not at a cutoff age for everybody. However, institutional arrangements would allocate people into the category of 'old' by dint of age. This creates an illusion of a single, monolithic, and homogeneous group of people labeled as 'the aged'. And this monolithic view does not do justice to older people because while particular patterns of symptoms and diseases might be associated with old age, older people's health conditions are as varied as those of younger age groups.

Culture-bound: Standardized Expectation of Aging

With the introduction of the modern working life, our understanding of the life course was divided into pre-work, work, and post-work phases (Kohli 1986). The normalization of fixed retirement ages ingrained the

definition of chronological old age starting at 65. Thus people tend to categorize people by age. It might be dangerous to do so because it makes the categories undebatable. We should be wary of the age-based categories. Besides, how to spend the whole life like the age at which to marry, start work, have children, retire, etc. is bound by cultural expectations. The normative expectations make certain behaviors appropriate at certain ages while others do not. Peter Laslett (1989) argues in his book that the indignity of old age originates from the lack of cultural meaning in the third age and he is dedicated to endowing the third age with new meaning.

By dating back to the origin of today's concept of the aged, we can see it is far from an objective definition but heavily influenced by early medical findings, problematized by societal and governmental administration, and fixated by cultural stereotypes. After evolving in the past century, our narrative of old age has been widely spread and taken root in the public. However, the negative rhetorics revolving around demographic aging form the basis for design decisions and can be scripted (Akrich 1992) to the technology for older people. Next, an analysis of today's mainstream technology for older people will demonstrate how our narrative of old age has become a liability to technology innovation for older people.

Pitfalls of Gerontechnology

Today's products are rooted in the going narrative of age. Following the thread of the analysis on the origin of current narrative of old age, this part extracts and summarizes the pitfalls that the mainstream technology for older adults (i.e. gerontechnology) to date easily falls into. To avoid going astray in technology design, it is imperative to be aware of the design pitfalls in the first place.

Pitfall 1: Neglect of Needs

First, the neglect of aging people's needs is exemplified by technology-oriented products that completely ignore older people's aging bodies and mental models built over their past decades of experience. Technology is developing at a dramatic rate, and it shows us the infinite potential of solving every problem we meet. However, we should be wary of being over-hyped and falling into the technology-utopian pitfall to leave every confronted problem to technology. The solutionist mindset might risk abuse of technology - 'we do it because we can'. This might lead to excessively packing features and functionalities into one product, namely, feature bloat, which inevitably increases the complexity of use and decreases the adoption rate. Bill Buxton (2001) argued such a trade-off between weak general and strong specific systems in his classic text on super appliances. Worse, this might lead us away from paying attention to aging people's needs and desires, further blind us from aging people's lived experiences, and let the obtrusive intervention of technology upset the balance in the ecology of aging (Forlizzi et al. 2004).

We do it because we can!

> *Robots used to have buttons or remote controls as interfaces; now it's all about screens that are made to look like faces—and we just talk to them. Cars used to have switches, buttons, simple displays, or custom consoles; now car controls are fully-fledged touchscreens. And the list doesn't just go on—it's about to explode! (Leonhard 2016)*

> *For those who believe in Terminal World, such as the business leaders whose companies focus on that trajectory, the goal is to produce and distribute more and more pixels, embed screens in every surface, make devices thinner, cheaper, crammed with more features and functions, and to sell two or three to every person on the planet. Then repeat. (Rose 2014)*

One example is the trend of screenification of products. Screenfication is enlisted by the futurist Gerd Leonhard as one of the ten mega-shifts. It is named Terminal World by David Rose (2014). He described the Terminal World as "passive, without personality", that "asserts a cold, blue aesthetic into our world". This can be validated by typing 'technology for older people' into Google. The loosely-accessed search result of a full page of screen-based products with few robots scattered therein may well reveal the dominant approach to technology design (Ijsselsteijn et al., 2020) in this impressionistic account (Figure 14).

As we age, both visual acuity and motor control skills tend to decline. Touch-sensitive areas are difficult to hit as eye-hand coordination declines. Accompanying the screenification is the disembodiment. Interacting with digital screens deprives us of our bodies. We are reduced to eyes, ears, and fingertips. Imagine interacting with something that you might frequently use every day, is such a reduced way of interaction good for people's overall well-being? We should take a closer examination of the manifestation of technology before it's too late when a structural change has already happened in people's lives on a mass scale.

Figure 14 A screenshot of the search results by typing 'technology for older people' into Google image (accessed on 28th August, 2022)

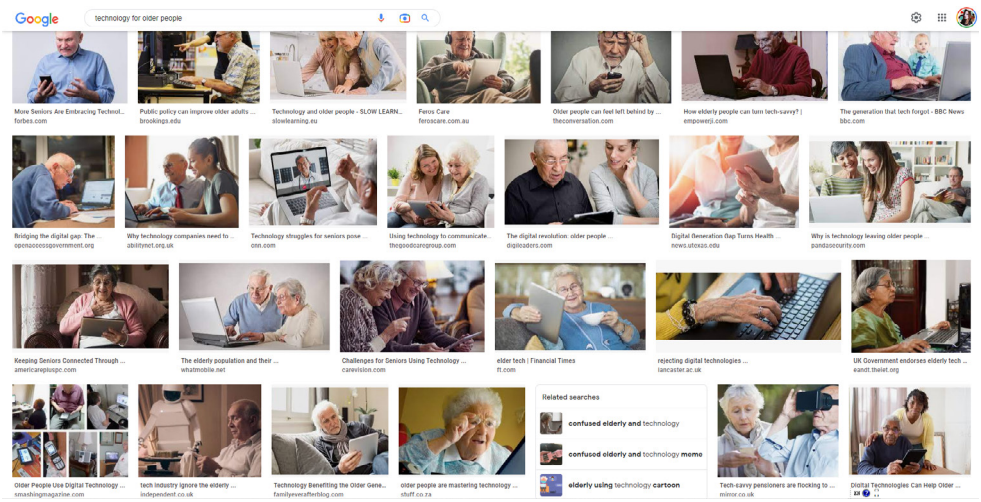


Figure 15 The GUI's mental model of a user (Igoe et al. 2004)

Pitfall 2: Overemphasis of Needs

> *Then there's the aesthetic problem. When products are developed for the aging, they tend to be ugly and an unwanted signal of fragility. As a result, people who need walkers or canes often resist. Once upon a time, a cane was stylish: Today it is seen as a medical device. Why can't we have walkers and canes for everyday use, to help us in everyday life, to carry our packages, provide a way to sit when we are tired, or view some event, and yes, to maintain our balance? Make them items of pride, stylish enough that everyone will want one." (Norman 2019)*

The opposing end of neglect is overemphasis which is represented by the stigmatizing or paternalistic products.

The products intended for older people in a stigmatizing way will certainly embarrass and alienate users. Admittedly, nobody wants to be framed as fragile and disabled. A necklace with a huge red button to press for help or a cane designed like a medical device, as complained by Don Norman, even though designed with good intentions to help, are horribly shouting 'you're old and dysfunctional!' all the time to its users. Since products reinforce social norms, such a negative way of seeing aging people that emphasizes their frailty and decrepitude, in turn, reinforces the problematic view imposed on older people. Interesting insights can be drawn from a simple comparison between eyeglasses and hearing aids, while the former not only correct vision but also are a desirable accessory but the latter are seen only as aiding devices to clarify sounds. The design and branding have much bearing on people's different impressions on the products.

Most time, designers are the ones making decisions on what is good for older people. When those design decisions are based on a distorted understanding of aging, it might lead to a paternalistic disposition of the artifacts. This is typically represented in a provoking speculative video by Superflux (2015), in which the protagonist, an old man, is monitored by smart objects that track his daily behavior including eating, sleeping, and walking, and the real-time data is shared with his children constantly. This monitoring system apparently creates unequal power relations between the senior and his children for older people's good and severely impinges on the older people's autonomy. One ramification could be forming a passive age script (Neven 2015) that

You're old and dys-functional!

Figure 16 An emergency SOS panic button alarm sends a customed message that has the current location of the person. (Access from https://seniorcaresingapore.com/smart/sos/)

Figure 17 A screenshot from a short film name uninvited guests which explores the friction between an old man and his increasingly smarter home (Superflux, 2015)

older people are forced to adapt to when no other options are available. In a similar argument, Loe (2010: 331) posits that instead of just relying on more assistive technologies, biotechnologies, or design techniques, the solution to aging in place may involve greater stress on continuity and autonomy.

Pitfall 3: Misunderstanding of Needs

Besides the two extremes described above, the third pitfall is the misunderstanding or incomprehensive understanding of aging people's needs including a strong association between old age and sickness or disability and a rigid stereotypical understanding of aging people's needs.

Originating from the biology-grounded definition of old age, the medicalization of aging is still predominant and can be reflected in the large proportion of technology aimed at medical purposes. A recent literature review of the quality of life of older people aging in place shows that the psychological domain receives far less attention in comparison with the physical domain (Vanleerberghe et al. 2019). This is not saying that physiological needs like health monitors or medicine are not important, on the contrary,

they are the basic needs that should be fulfilled to achieve higher-level needs according to Maslow's pyramid. However, innovation should also go beyond those basic needs and explore a much larger field such as social connection, self-fulfillment, knowledge acquisition, etc.

Another common misunderstanding about aging people's needs is to view them as static and defined ones to be satiated by technology-enabled products. Such a deterministic view of technology sees users as receptors of a prescribed technology scripted by professionals. The "technological determinism" limits the view of technological potential to the stabilization of its functionality (Rodeschini 2011). The unintended use of technology that goes beyond the ones proposed in the design phase is carefully avoided. However, the world changes constantly and so do older people's needs and daily life. The fixed and rigidly prescribed design will definitely render the relationship between older people and technology out of sync. An example here is a medicine dispenser that stores all pills in a container that gives prompts to take pills at the certain time. This rigid model has no way to cope with the situation where people miss the audio prompts when they are not at home. Furthermore, people might find it obstrusive, impersonal, or embarrassing to be alerted at inappropriate time hence deliberately ignore the alerts. Besides, the narrow-scripted designs also deny the possibility of innovative ways of use and cannot adapt to various situations over time.

Conclusion

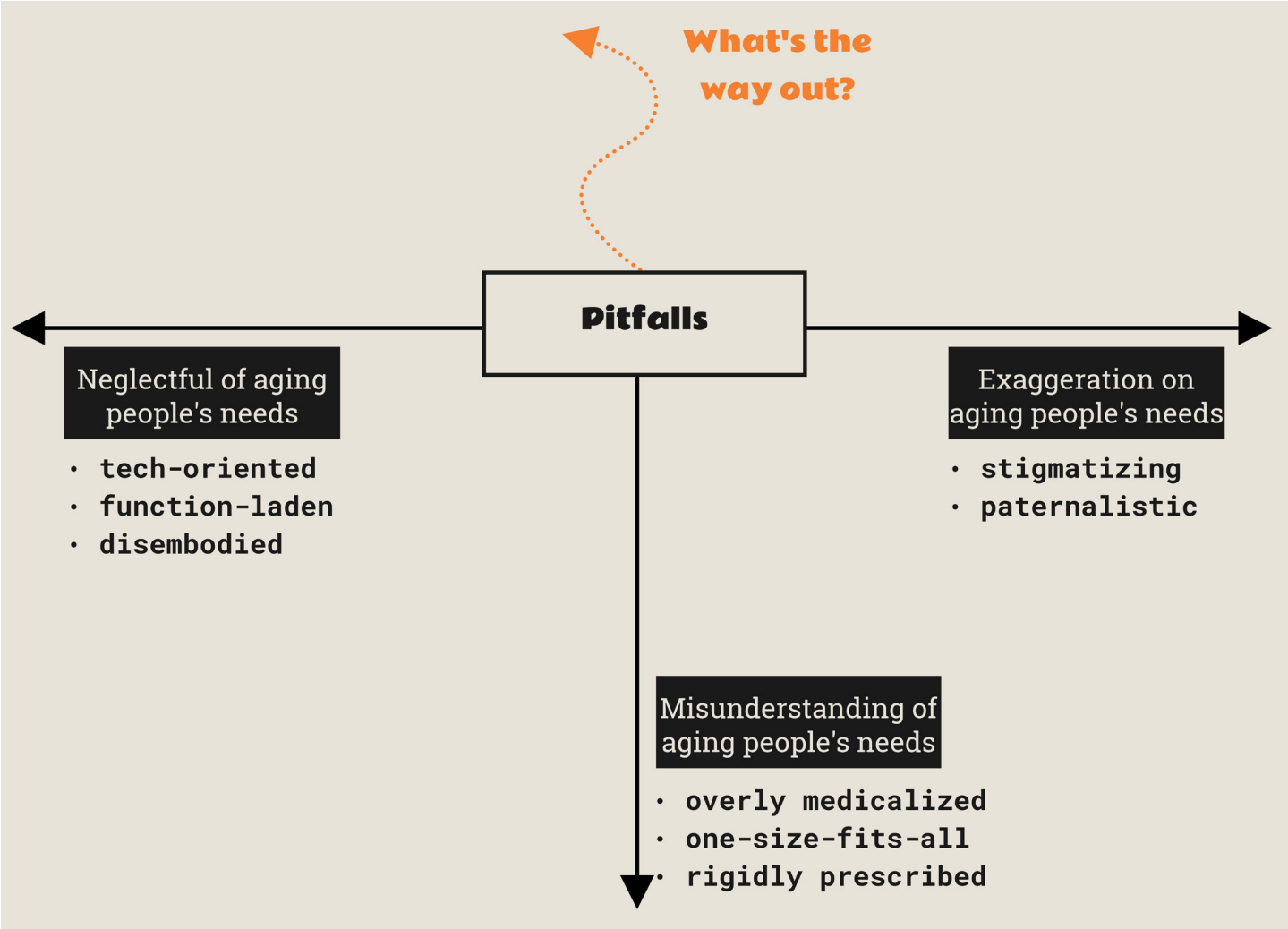
Now we have known that the origin of current notion of old age is partly biology-rooted, partly social-constructed, and partly culture-bound. So what is wrong with our understanding and how might it lead to the various pitfalls in technology design we face today? We will answer these two questions to conclude this chapter.

First, there is a tendency to view aging from a deficit-driven perspective deriving from the medical theory in the 19th century. For over a century, the idea that old age is synonymous with unhealth, insanity, and incapability of economic production prevails. These stereotypical and ageist characteristics imposed on older people lead to the stigmatizing products we see in the market (pitfall 2). They tend to infantilize older people, exhibit a paternalistic disposition, and hinder users' autonomy.

In the same vein, the medical origin leads to a partial view on aging only from a medical perspective. We see old age as a medical problem to be solved. The medicalisation of aging is further strengthened by products and marketing of which large proportion purely focus on physiological or healthcare-related fields.

In the 20th century, the problematized view on the aged population has instigated many beneficial government programs including pensions, nursery homes, etc. which have protected a great

Figure 18 Three types of pitfalls



number of older people from suffering financial deprivations or loss of care. However, it is these programs that categorize people purely by age that give us an illusion of a single, monolithic, and homogeneous 'aged' group of people who constitute a societal crisis to be addressed. Besides, this might also mislead us into viewing aging as an aggregation of certain static features. This leads to the rigid design prescribed by the professionals which ignores the diverse personal needs of individuals and everchanging complex situations of daily lives.

Now that the misconceptions developed over the past century have been identified as well as the pitfalls current gerontechnology might fall prey to, the next question would be how to overcome the misconceptions to avoid the pitfalls. Several theories and projects that shed some light on the question will be introduced in the next chapter.

Takeaways

- Ignoring older people's needs might lead to tech-centered, function-laden, and disembodied products. Over-medicalized view on aging leads to partial understanding of aging needs and over-simplified view blinds us to the diversity and dynamic of needs thereby leading to one-size-fits-all or rigidly prescribed solutions. Exaggeration on needs distorted by a problematized view might result in stigmatized and paternalistic products. So, what is the way out?

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New Voices

NEW VOICES

Despite the prevalent misconceptions described in the previous chapter, it is a relief to see there are many new voices attempting to overturn the predominant view on old age. This chapter will introduce some of the theories and projects that inspire this project's stance.

Successful Aging Model

Rowe and Kahn (1998) described successful aging in a multidimensional way,l that encompasses the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities (Figure 19). This model shows a broadening and integrated perspective compared with prior biomedical models which are preoccupied with disease and disability (Seeman et al. 1994) or psychosocial models (Leonard 1981) which focus on social participation, psychological resources, etc. A few years later, an expanded version of the successful aging model complemented the original concept with a body of theoretical inquiry and empirical research at the level of society. Three main goals for scholars are identified, among which adopting a life course perspective calls for redistribution of life major activities, and focusing on human capital calls for more attention being paid to the potential upside of the aging of society (Rowe and Kahn 2015).

There are similar models such as the biopsychosocial model (Havelka et al. 2009) arguing that a more comprehensive approach should be taken to address health and disease. Yet, the successful aging model is one of the earliest and most influential models defining

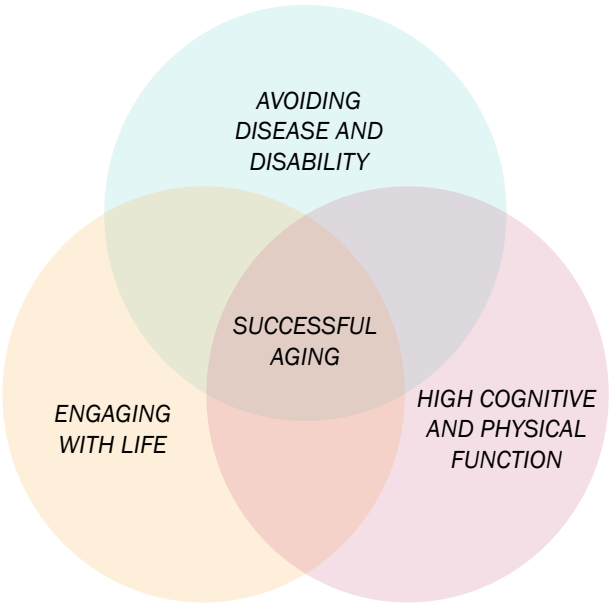

Figure 19 a model of successful aging adapted from Rowe and Kahn (1997)

aging as a multidimensional process that requires attention to more than diseases. It set the stage for later intervention studies to increase the number of people aging successfully. The expanded version provided a developmental view and inspires a positive way of looking at aging.

Personhood Turn

In the context of care, the desire for a personal relationship with care professionals instigates the development of the care models which turned from a physician-centered system to patient-centered care (Institute of Medicine Report 2001). It is then followed by an argument that patient-centered care should be supplemented by person-focused care. While patient-centered care generally revolves around disease-oriented episodes, person-focused care "is based on the accumulated knowledge of people, which provides the basis for better recognition of health problems and needs over time and facilitates appropriate care for these needs in the context of other needs" (Starfield 2011). More recent research shows more attention to relationships and argues that the formation and maintenance of relationships in health care should include the personhood of participants and positive relationships are crucial to well-being (Beach and Inui 2006). This strand of development in care models indicates the importance of taking personal experiences and values into account.

This personhood turn calls for a person-centered approach to care. It also inspires a personal view that pays attention to lived experience and embraces the deeply personal, multidimensional, and rich qualities of the aging process.

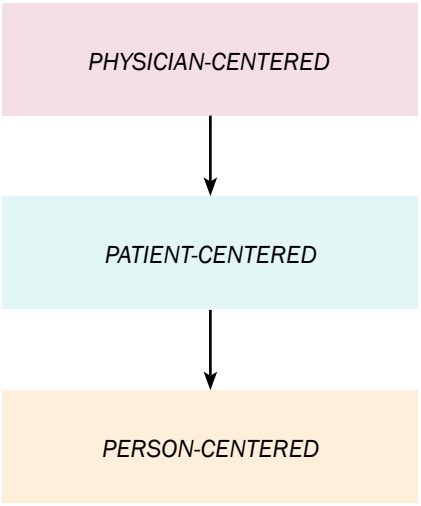

Figure 20 a personhood turn i the care model

Inspiring Projects or Cases

Apart from the inspiring theories that point out the proper way of viewing the aging process, many design cases or projects encountered during the literature research also serve as a source of inspiration for this project. A few will be briefly introduced next.

Resourceful Aging (Nicenboim et al. 2018; Kitazaki 2019) is an EU-funded project that spanned over five years. It started by questioning the negative narrative around older people and attempted to take a positive perspective on aging by focusing on what the elders are still capable of. It integrated ethnographic research results with machine-learning-enabled thing-centered research findings and yielded an in-depth understanding of older people's emerging resourcefulness in their daily life. Accordingly, its final proposal aimed at empowering older people to age resourcefully by providing a set of connected resources that can be actively used in creative ways (Figure 21).

Warm Technology (Ijsselsteijn, 2020) is a novel perspective on design for people living with dementia. It pointed out that current technological innovations are often driven by technology-centricity rather than user-centredness thereby causing the mismatch between the dominant solutions offered by technology and personal needs. To challenge conventionally impersonal and uncaring technology, it advocates Warm Technology which is predicated on (1) the focus on skills older people possess or wish to develop; (2) the purpose to support social and emotional needs and enhance feel-good moments; (3) the goal to be empowering thus increasing self-efficacy; (4) the aim to be non-stigmatizing and acknowledge

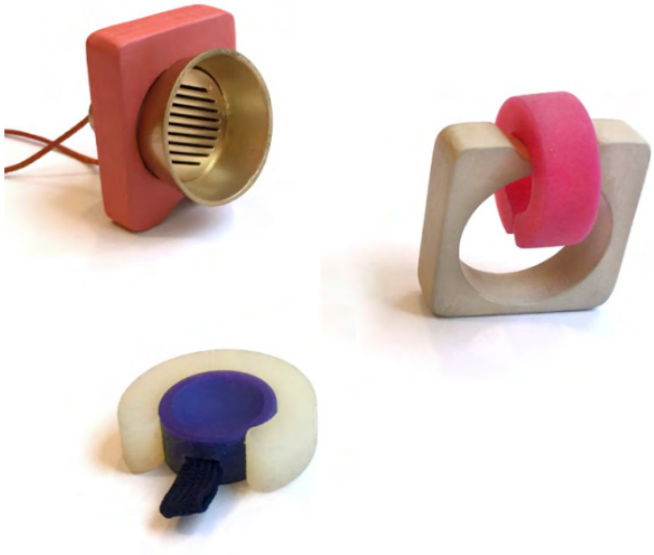

Figure 21 Connected Resources (Nicenboim et al. 2018; Kitazaki 2019)

the diversity; (5) the basis of natural sensory and motor system and personal context and history. This approach is instantiated by a series of design cases including Stay-Tuned Radio (Wintermans et al. 2017; Figure 22), Homing Compass (Brankaert and Suijkerbuijk 2019; Figure 23), and VITA Music Pillow (Houben et al. 2020; Figure 24).

Other projects or design cases including markerClock (Riche and Mackay 2010) and Walky (Nazzi et al. 2012) promoting peer support and social connectivity, eHome project supporting self-awareness and reflection (Fitzpatrick 2012), etc. all have been inspiring to this project by showing new opportunities for technology design for older people. Taking agency, adaptivity, and social reciprocity as the core values, these cases manifest different attempts of tweaking the negative rhetorics around gerontechnology and reimagining new ways of living enhanced by technology embedded in everyday life.

Figure 22 Stay-tuned radio (Wintermans et al. 2017)

Figure 23 Homing Compass (Brankaert and Suijkerbuijk 2019)

Figure 24 VITA Music Pillow (Houben et al. 2020)

Conclusion

To conclude, the theories and design cases introduced in this chapter have greatly inspired this project. The holistic approach promoted by the successful aging model together with the personal uptake inspired by personhood turn in the care model points out a promising direction to maneuver through misconceptions. Design projects and cases that share a positive view of old age exemplify the manner of affirming, exploiting, and promoting the potential and possibilities in old age. Emphasis on a contextualized understanding of lived experiences serving as the input for technology design is another recurring theme among the projects that can be assimilated. Bearing the prompt of taking a holistic and personal approach to understanding in mind and taking a positive viewpoint, we still need to go through the hands-on exploration to glean first-hand insights. Therefore, the next question would be how to truly understand older adults' life practically.

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Prologue: Capability Approach

Capability Approach

To answer the question brought up at the end of last chapter, the Capability Approach (CA) and a capability theory will be introduced. It is a theory threading through the whole project. In particular, it provides a theoretical foundation to develop a methodological path to probe into older people's lives in a comprehensive way through semi-structured interviews (Chapter 3) and constitutes an important part of analyzing the final evaluation sessions (Chapter 7). This chapter will answer what the CA is by introducing the most important concepts relating to this project. Why the CA can be used to assess individuals' overall well-being and how the CA can be brought to bear on design and technology will be elaborated on in the last two sections which briefly describe the relationship between CA and well-being/technology.

Capability Approach (CA) and Capability Theory

In opposition to measuring the overall welfare of a country by looking at Gross Domestic Product (GDP), the capability approach theorists argued that what people can do and be should be measured to assess people's well-being. The capability approach (CA) pioneered by Martha Nussbaum and Amartya Sen, has become an influential framework for reflecting on justice, equality, well-being, and development (Oosterlaken 2013, p.41). The difference between the capability approach and capability theory should be noted here. As explained by Robeyns (2017, p.29), the capability approach is an "open-ended and underspecified framework, which can be used for multiple purposes" and there are various ways to "close" it. When the capability approach is specified for a specific use, it is proposed to be called a capability theory.

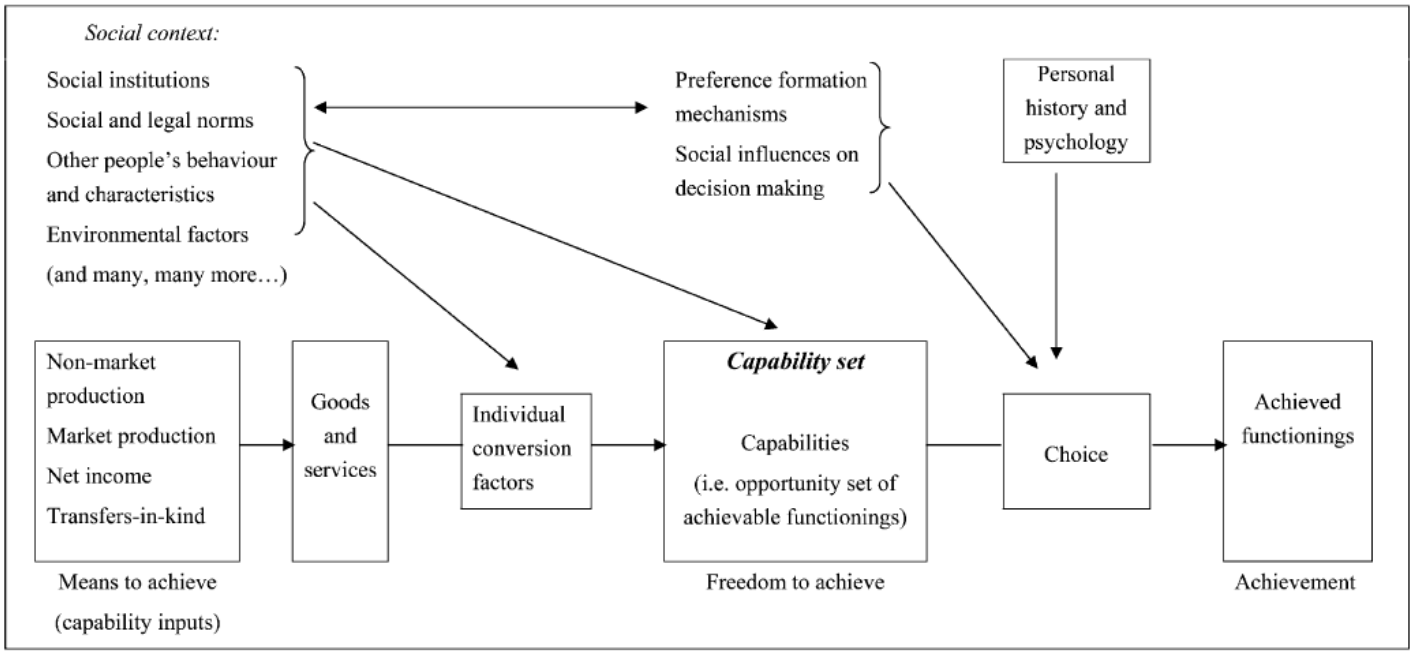

Figure 25 a stylised non-dynamic representation of a person's capability set and her social context (Robyens 2017)

Key Concepts in Capability Approach

Functionings and capabilities

Functions and capabilities are discriminated concepts and are essential to every capability theory. Functionings are about the realized, while capabilities are about the effectively possible (Robeyns 2017). What functionings and capabilities are positive is a normative decision made by a specific capability theory.

Conversion factors

Besides, conversion factors "determine the degree to which a person can transform a resource into a functioning" (Robeyns 2017, p.45). Figure 25 shows the relationship among means to achieve, capabilities, and achieved functionings.

The consideration of conversion factors enables this capability theory accommodate both universalism based on a universalist conception of human well-being and particularism in terms of how universal values are realized.

In this project, Nussbaum's capability theory is chosen as core base of the following research. Nussbaum (2006) made a list containing 10 central capabilities that every human being should have to live with dignity (Figure 26). Please refer to Appendix A for a full definition of each capability given by Nussbaum.

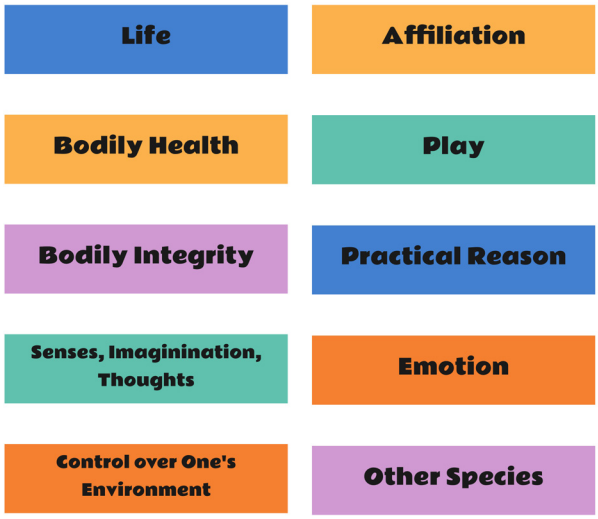

Figure 26 A list of central capabilities brought up by Nussbaum (2006)

CA and Well-being

As introduced by Robeyns (2011),

> *CA is generally understood as a conceptual framework for a range of normative exercises, including most prominent the following: (1) the assessment of individual well-being; (2) the evaluation and assessment of social arrangements; and (3) the design of policies and proposals about social change in society.*

Informed by the personhood turn described in the previous chapter, we see the importance of taking a holistic approach while addressing the well-being of older people. However, concepts like well-being or quality of life are never easy to define. Oosterlaken (2013) proposes that human capabilities can be seen as the implicit or 'missing link' between more comprehensive ideas of the good life and concrete technical artifacts. Therefore, the CA offers a proper way to assess people's well-being in terms of capabilities. Nussbaum's capability theory provides a concrete and substantive normative foundation (Jacobs 2020) for probing into older people's lived experiences and well-being. The probing toolkit developed on the basis of the CA will be elaborated on in Chapter 3.

The CA and Technology

On understanding the relation between technological artifacts and human capabilities, Oosterlaken (2013) posited that moving back and forth between 'zooming in' and 'zooming out' is required: while the former 'allows us to see the specific features or design details of technical artifacts', the latter 'allows us to see how exactly technical artifacts are embedded in broader socio-technical networks and practices'. From the perspective of CA, evaluation of the outcome brought by technological artifacts can be done by examining whether the resulting expansion of human capabilities is of intrinsic value, whether the outcome accommodates diverse individuals, and whether the process leading to the outcome respects human agency.

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Takeaways

- The CA can be a solid theoretical base for different research or design activities, which include probing into people's life, assessing people's well-being, eliciting people's needs and desires, inspiring design goals, evaluating and reflecting on the ethical aspects of technical artifacts, and so on. Chapter 3 and chapter 7will show how the CA weaves throughout this project.

Interview

INTERVIEW

In-depth interviews with older people were conducted to extract situated knowledge about the target group. This chapter describes the empirical study conducted by the author, which includes the background, used methods, procedure, and findings.

Background

The previous research has unfolded the main theoretical underpinnings that informed this project and illustrated the understanding of the state-of-the-art of mainstream gerontechnology. While the successful aging model and the personhood turn are spotted in the literature research, an in-depth understanding of aging people from a holistic perspective was needed. Therefore, five semi-structured interviews with the target group were conducted to know their needs, challenges, and desires in daily life.

The main aims of the one-on-one interview were:

- To make the first acquaintance with the participants and establish trust;
- To get to know them as whole persons;
- To extract the richness of their lived experiences;
- To understand how they interact with technological products currently and their attitudes towards them.

Method

Five in-depth interviews were conducted one-on-one with aging people (aged over 65 years old). The main purpose was to get to know the participants' life and establish trust for follow-up sessions, semi-structured interviews were supplemented with a card set created based on the capability theory by Nussbaum to make the interview more dynamic and entertaining. The open-ended questions open up the free space for exploring emerging topics during the process (Patton, 2002).

Participant Screening and Recruitment

The screening criteria were established on the age range and the ability to speak English. As the author and researcher can only conduct the interview in English, the participants are narrowed down to English-speaking aging people in the Netherlands. The limitations of recruiting this subset of aging people in the Netherlands will be discussed in the last section of this chapter. The recruitment process was done by utilizing the author's personal network and a snowball sampling technique.

Table 1 shows the demographics of the aging people who were interviewed. The participants' names have been changed for privacy considerations.

Participant Name	Gender	Profession	Age
Emily	Female	Health care manager	72
John	Male	Initiative Chairman	74
Anna	Female	Photographer	68
Tina	Female	Teacher	74
Robert	Male	Writer	70

Table 1 Demographics of participants (all names have been changed)

Ethical Considerations

All the study including the data management plan has been supervised and approved by the data steward of Industrial Design Engineering (IDE) and the Human Research Ethics Committee (HREC) of TU Delft. An informed consent form with a description of the project has been created and sent to the participants to get the approval of conducting the interview before starting. Please refer to Appendix L for the full version of the informed consent form.

Procedure

Four out of five interviews were conducted at participants' places while one was at a cafe according to participants' preferences. The whole process was composed of 3 main activities. Table 2 shows the overview of the interview.

Opening

The participants were asked to read and sign the informed consent. After that, the interviewer briefly introduced the background of the project and let the participant ask questions they have before officially starting. The permission of recording was then requested.

First activity (Warm-up)

The participant was asked to describe what a typical day in his or her life looks like in the form of a timeline.

Second activity

The participant was provided with a set of cards with a topic and several guiding questions revolving around that topic. There were twelve cards (Figure 28) in total and they were presented to the participant in three rounds (each round with four cards). The participant was asked to choose the topic he or she feels like sharing and was not requested to cover all topics. Only one additional topic related to technology (the black card) was a compulsory one, which lets them share their feelings about the digital products they use currently.

Third activity

The participant was shown a diagram of a human body, in which some common devices or accessories related to different body parts were listed. A list of digital functions was provided on another sheet of paper. The participant was asked to associate one or several functions with the device or accessory that was most desired to be endowed with extra functions, namely, to be 'smartified'. Participants can choose more than one device and share their thoughts on how they would like to use the 'smartified' devices (in what kind of situation).

Gift

In the end, the participant was given a self-printed postcard as a gift (figure 27) and was invited to attend a follow-up session in the future.

Figure 27 A self-printed postcard as a gift

Aim	Activity	Guiding Questions	
- To know their life stories - To understand how they perceive their current relation with wearable 'things' - To know their technological preferences	Warm-up and Ice-breaking → Share your life stories 1 → Share your life stories 2 → Wearable Tech		
- Greetings	- Warm-up & introduce - Sign informed consent	- Ask for permission to record - Do you have any questions before we start?	5 min
- To know their life stories (daily activities & hobbies)	[A1: One day] - Describe what one typical day is like for you	As a warm-up, could you imagine if you have one day to plan freely, how will you schedule it?	10 min
- To know their life stories (challenges)	[A2: Choose and share] - Select the topics you wish to talk about - Choose based on your intuition (challenging, interesting, enjoy, desires, wishes)	Next, I will show you several topics. Under each topic there are some related guiding questions. We don't need to cover all of them. Just choose those that you most feel like sharing. You can share what you feel enjoyable, challenging, or desired related to each topic.	45 min
- To know their technological preferences - To understand how they perceive their current relation with wearable 'things'	[A3: Wearable Tech] - A peek into smart wearables	Let's talk about wearable tech. - Do you have experience in using smart wearables? Here's a diagram to help you recall all of those possible wearables on/in our body. Let's imagine that we can choose one or more parts to embed smart systems that can, for example, collect your bodily data, connect with other devices, give you notifications, etc. where would you choose? - Here are a set of functions that can be integrated in. What do you think of them?	30 min
		Thank you very much for attending! - Ask for inviting back.	

Table 2 An overview of the interview process

Data Collection

Probing Toolkit

A set of cards (Appendix E) were designed to serve as a conversation starter. The topics of the cards were extracted from the ten central capabilities in Nussbaum's capability theory (see chapter 2). Nine capabilities including (1) bodily health, (2) bodily integrity, (3) senses, imagination, and thoughts, (4) control over one's environment, (5) practical reason, (6) play, (7) affiliation, (8) emotion, and (9) other species were selected to develop the topic cards. Life was intentionally excluded. According to the definition by Nussbaum, life is the capability to live to the end of a human life of normal length. It can be understood as the capability to exist in the world untill old, which is the prerequisite to make this interview happen so was left out of in the interview. The guiding questions were generated according to the author's understanding of those capabilities. The topics presented in each round were clustered according to the internal relations among the capabilities found in the previous workshop (see the intermezzo of the chapter 3 prologue). Though developing the card set was based on the capability theory, the investigator deliberately eschewed the word capability in interviews to avoid the shame or uncomfortableness caused by the rhetoric of capable/ incapable. The participants were encouraged to share anything related to the topic and not to be restrained by the guiding questions.

Another material is a visualization of the human body to help the participants better think of the potential devices and a list of digital functions introducing the technologies that older people might not be familiar with (Appendix F).

While the tangible materials were used, inquiry questions were asked to gently guide th econversation and reveal the challenges, desires, and needs. Notes on non-verbal communication were taken by the investigator during the process.

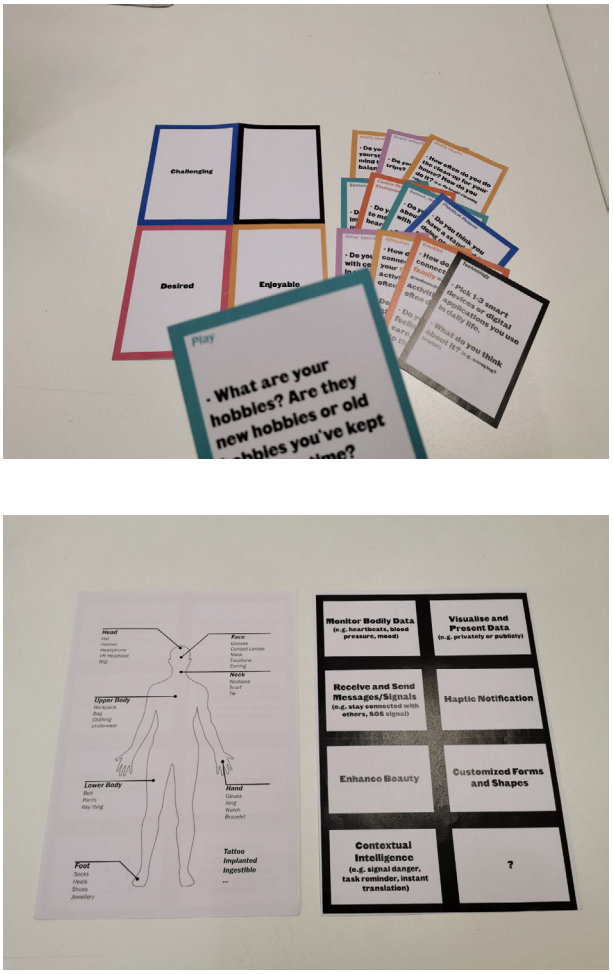


Figure 28 a&b Probing toolkit for activities in the interview

Data Analysis

Hybrid coding

The recording of the interviews was first transcribed and then the investigator first obtained the initial codes by using a mix of types of coding including deductive coding and inductive coding. The deductive coding started with priori codes based on the nine selected central capabilities. The used ways of inductive coding include in vivo coding, process coding (observations of non-verbal communications), structural coding (based on demographic attributes including profession, interests, etc.), and values coding.

The coding process consisted of an initial coding to get familiar with the data and line-by-line coding to dig deeper, refine the codes, and code as much as possible. Memos were taken all the way along the coding process to extract meaning from the data, document the coder's emerging thoughts and doubts, and open later discussions (Birks, Chapman, & Francis, 2008). Figure 29 gives an impression of the table of codes.

Please refer to Appendix G for a complete table of codes with memos.

Code	Comment
• [control over one's environment] - should let voice be heard by the municipalities	
• [emotion] - family union on holidays, joking and laughing	
• [memo] - anywhere on the body is fine as long as it makes sense	
• [memo] - changing the form and shapes might help	- minimalize to make it less noticeable- stylish shapes
• [memo] - medium	- old people are used to certain traditional mediums (e.g. manual customer service) than others

Figure 29 Table of initial coding. Screenshot from Microsoft Excel.

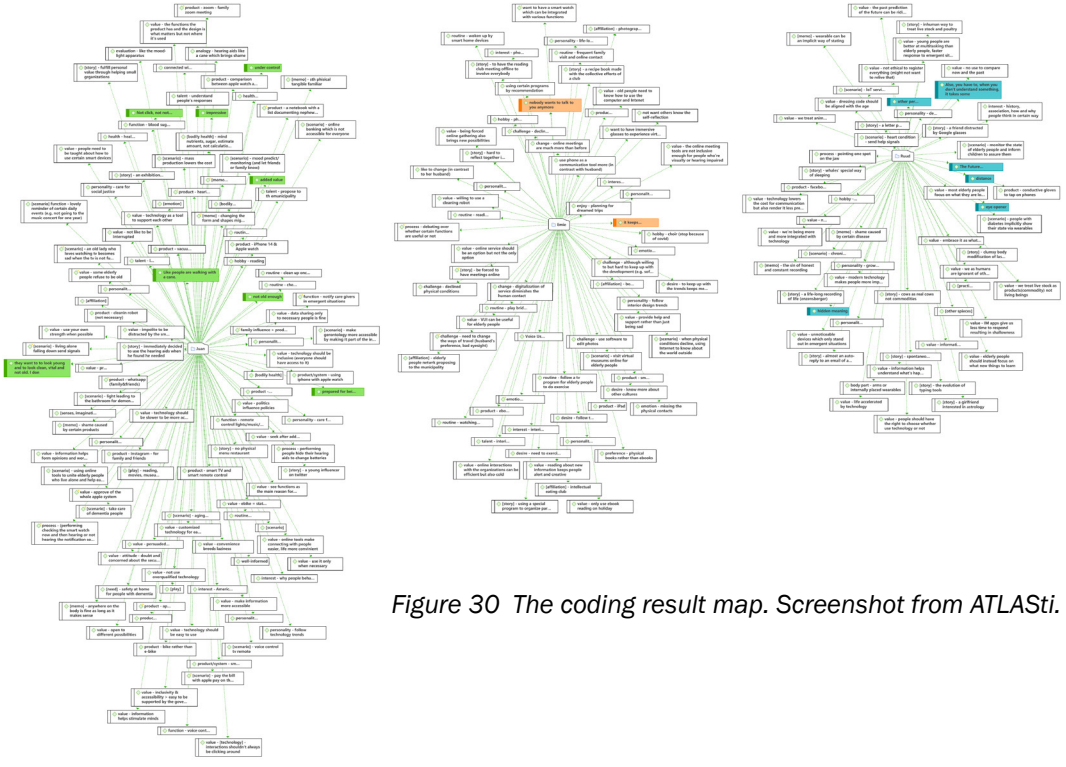


Figure 30 The coding result map. Screenshot from ATLASti.

Clustering and Analyzing the Data

The outcome of the previous coding process is a map of codes shown in Figure 30 (See Appendix H for a high-resolution version). The transition from the data to themes was completed by clustering the initial codes obtained from the previous step and analyzing them with extended themes that categorize the data. The analysis methods used here are thematic analysis, frequency and discourse analysis. The identified six themes were listed below.

- ***Personal traits***

  This cluster includes all traits that can describe the participant as a holistic and vivid person like the profession, hobbies and interests, typical quotes, personal stories, and personalities extrapolated by the investigator.

- ***Topics and lived experiences***

  This cluster includes the life stories, needs, values, and challenges explicitly or implicitly stated by the participants.

- ***Attitudes toward technology***

  This cluster collects the different attitudes explicitly or implicitly expressed by the participants and is classified into three categories: avoid/arguable/promote.

- ***Factors on the adoption of technology***

  This cluster focuses on the factors that might influence the adoption of certain technology.

- ***Thoughts on aging***

  This cluster illustrates the participants' thoughts on aging which also shed some light on their values.

- ***Mentioned scenarios***

  This special cluster is formed by all the scenarios, no matter imaginary or real, mentioned by the participants which also implicitly reveal what the participants are concerned with.

Vignette writing

To avoid losing the richness of the raw data, the cluster of lived experiences formed in the previous step combined with participants' values and mentioned scenarios were revisited carefully by the author to create three vignettes that represent small scenes that illustrate and support summary assertations (Graue & Walsh, 1998). These vignettes also serve as inspirations for initial concepts.

Findings

Thematic Analysis Result

Topic frequency

According to the frequency of codes in the second cluster, the most frequently mentioned capabilities are bodily health, senses imagination and thoughts, emotion, and affiliation. See below for the detailed sub-topics.

Bodily health

- declining physical states
- declining memory
- chronic diseases
- emergent situation
- healthy diet
- introspection on mood

Senses, imagination, and thoughts

- connected with the outside world
- follow the trends
- know and understand what's happening

Emotion

- keep in contact with family members

Affiliation

- making friends
- loneliness
- social interactions

Attitudes towards different product features

The classified attitudes toward certain product features mentioned by the participants were shown below.

- Avoid: features that need to be avoided

- Arguable: features that are arguable

- Promote: features that are desired to be promoted

Avoid

- information overload
- distraction
- laziness
- fast
- stigma
- compulsory and restrained

Arguable

- embedded in a larger system
- data sharing

Promote

- health management (bodily data monitoring, food intake, sleep analysis, pedometers ...)
- social interaction (making friends, social activities)
- working efficiency
- meaningful information
- option to opt-out
- independence
- physical contact
- embodied interaction
- inclusive
- easy to use
- privacy
- security
- multimodal interaction
- autonomous
- life-saving

Vignette Writing

Three vignettes were captured by the investigator. They were extracted to keep the richness of the raw data hence served as indispensable supplements to previous analysis. They are also essential to the later definition of the design vision.

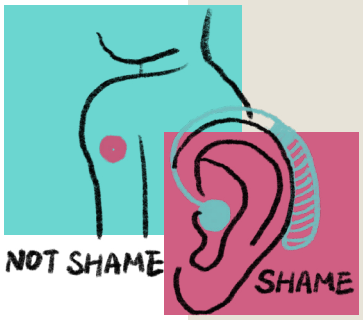
Vignette 1\ This vignette captured two seemingly contrasting descriptions of the devices used by aging people. In the first case, the hearing aid was deemed shameful to use while in the second case, the measuring button used by the diabetes patients was not.

Implication: the ways how people frame the devices - a signifier of decrepitude (negative) or diseases (neutral) - influence people's attitudes. It also demonstrates people's framing of the product influences their willingness to adopt it. The framing includes aesthetic feelings, attached meanings, and positioning.

Vignette 2\ The book club gatherings were forced to be online during Covid times. In the beginning, this brought difficulties in using online tools. Later, the online scenario, in turn, stimulated the idea of co-making a Christmas recipe book together that can be easily shared.

Implication: The second case inspires the prospective direction of design for emergence. While we as humans all love serendipity, however, it is not easy to curate serendipity. The line between serendipity and accident is thin. Design for pro-social unexpected use without prescribing a rigid way of use might be a potential way to empower users. Giving the power of control

Vignette 1 Shame or not



"The patient with the button attached on the skin doesn't need to explicitly claim to have diabetes. The button implicitly shows the state, which avoid the awkwardness to explain verbally. [Robert]

Most aging people are kind of ashamed to wear hearing aids and they want to hide their dysfunction of bodies. It's like people walking with a cane. [John]

Vignette 2 Emerging activities

"...being forced to have online gatherings also brings new possibilities [Emily]

back to older people helps build autonomy and increase self-efficacy.

Vognette 3\ When asked to imagine what extra functions can be added to the selected device and the related use scenarios, one participant chose the glove and imagined that in an emergent dangerous situation, an SOS signal can be automatically sent to the family and friends on the tapping of fingers.

Implication: The third snapshot foregrounds the substantial significance of bodily movements. Given that older people might face gradual changes in their motion systems, it is important to support natural interactional actions in the first place, such as voice user interfaces (VUI) or tangible user interfaces (TUI) rather than promoting unusual affordances or arbitrary conventions (Norman, 1999) that need to be learned.

Vignette 3
Body movements

...by doing this [tapping fingers] you can do this to send SOS signals secretly [Anna]

Reconceptualizing Aging

The statements below are synthesized from the interviews. They are investigator's attempts to reconceptualize aging.

Aging does not happen overnight.

We tend to view aging to be a totally sepertate state from being youth or middle-aged. However, aging is not a singular stage. Needs or desires might change chronologically.

> *I want to keep up with the latest developments. It keeps me young and energetic. [Emily]*
>
> *I am interested in technological innovation. I think they can be affordable for most people in the near future and help many people. [John]*
>
> *I always do volunteer work. [Tina]*

We have a lot of stereotypes about older people. However, they seem to be a population that consistently defies expectations. This confirms that the notion of old age needs to be revised. Being old doesn't equal being dependent, incapable, fragile, etc. Many older people are still physically fit, live independently, are full of passion to learn, and eager for self-actualization, etc.

Aging is complex and deeply personal.

All participants were recruited based on one demographic characteristic they have in common - age over 65 years old. However, after conducting the interviews, I found that age is the least important label on them. Maybe I shouldn't be surprised because they are different individuals after all. Accordingly, this indicates that every older person ages differently. The frequency analysis from the thematic analysis might reveal the topics of most concern, but the richness lies in the differences, and the uniqueness of every person's life shouldn't be ignored.

Attitudes towards aging are different.

I was not only deeply impressed by their colorful life experiences, but also by the positive attitudes they exhibited during conversations. Many of the participants showed a great capability of adapting to the shrinkage of certain capabilities, for instance, the declining physical conditions, by focusing on what they still can do.

> *I used to do outdoor sports like hiking a lot. But because of him [my partner], we do less intensive traveling now. [Emily]*
>
> *Most people of my age are complaining about how they're getting older and what are some things which they cannot do anymore, etc. But I still have so much to learn about the world around it. [Robert]*

The participants recruited in this project to some extent, are all successful-aging representatives who maintain well-being by marrying aging limitations to selectivity with optimization and compensation(Baltes & Carstensen, 1999). This means that older people reduce the number of options they consider in life (selectivity) by optimizing their remaining talents (e.g. what Emily and Robert do) and/or compensating for those that are deteriorating. Dury et al. (2018) framed those compensations as balancing factors which include individual-level circumstances, environmental influences, and macro-level features.

The well-being paradox, where older persons experience high levels of well-being regardless of age-related declines, confirms that physical frailty does not definitely negatively influence the perceived quality of life while psychological factors contribute most (Vanleerberghe et al., 2019). This

also indicates that despite a similar process of physical declination, the attitudes towards it might vary from person to person.

Sum-up

Our society abounds with misconceptions about aging at odds with reality. This, in turn, opens up the opportunity space for designers to rethink the notion of aging to better design technological systems. The nuanced dynamics, diversity, and complexity of aging should be taken into account and the focus should not only be on the deficits but also the capability of older people.

Discussion

Probing Toolkit

The probing toolkit designed by the investigator worked well to engage the participants and make the interview more dynamic and interesting. The abstraction of the topics extracted from the capability theory was concretized by the guiding questions. The freedom of choosing the topics to talk about alleviated the pressure of sharing personal life. Overall, the card set served as a good conversation starter to obtain a comprehensive understanding of the life of the participants.

The human body diagram and the function list worked well to generate interest and stimulate the imagination of the participants. Many of the participants actively speculated on the possible products in the future by associating the function and the device.

Data Analysis Methods

The investigator deliberately chose the methods of analysis to identify patterns as well as extract the richness of lived experiences. Therefore, hybrid coding methods were used. Furthermore, besides using the usual methods of thematic analysis by clustering to surface patterns, nuances in the data were kept in the vignette writing. The general insights gleaned from the interviews were documented as the result of a holistic analysis. The combination of different methods in analysis contributes to remaining the richness of data and serves as a solid step toward the framing phase.

Limitation of Sampling

The main limitation of this study was the language. As the interviews can only be conducted in English, this might already filter out a certain part of the target group. For example, the Dutch participants must be literate enough to speak English which means aging people who are not that literate might not be represented by this sample. And the expression of the participants might be limited by using a language that's not their mother tongue. Besides, the recruiting of the participants was through the personal network and two out of five participants work in the creative industry and are still actively working, which might not be congruent with the usual situations of retirement.

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Takeaways

- How we categorize people connotates what stance we take to view them and decides what we can see from that perspective.
- Aging is a developmental, complex, personal process. Different people face it with different attitudes, which very much influences their well-being.
- The nuanced dynamics, diversity, and complexity of aging should be taken into account and the focus should not only be the deficits but also the capability of aging people.
- Defining the aging people by age might lead to many blind spots resulting in incongruence with the reality. This chapter tried to overturn the current notion of oldness and aging from a different perspective predicated on capability approach.

Intermezzo:

A Few More Words on the Interviews

When we talk about designing for older people, we're inclined to focus on the common patterns existing among this specific age group, which makes much sense. However, this might make us blind to the richness lying in the differences in their life.

After conducting the interviews, I was awed by how different they are, which made me reflect on the label 'older people' I put on them. Given that they are so different, does it make sense to categorize them by age? Admittedly, the way of categorization already connotes a certain stance to frame the problem. For example, the definition of older people associated with being aged over 65 might stem from the observation of the pattern that certain diseases are more likely to occur among people over 65 (which was mentioned in the biology-rooted discourse around old age in chapter 1). Hence, age can be seen as one lens through which to segment the human cohort. This also makes me more aware of the limitation of using age as the only way to categorize people. Put aside their ages, it is unfair to say that they are all alike.

So, are there other ways to better understand people in a more fine-grained manner? In terms of design, what lenses shall we use to avoid the negative rhetorics mentioned in chapter 1?

There are of course other lenses we can use to categorize people. The capability theory can be one possible answer. From the capability perspective, people can be featured by certain needs, desires, challenges, etc. Besides, this point of view avoids the drawback of categorizing people by age, which is seeing aging as a single monolithic state. In fact, aging is not a singular stage. Needs or requirements might change chronologically, which can be reflected in the capabilities. This accordingly poses new challenges for finding one-size-fits-always solutions instead of one-size-fits-all solutions.

Besides, the capability expansion or shrinkage over the course of a lifetime should be viewed as natural. Instead of asking 'how might we compensate for capability shrinkage' we can frame the question in another way: how might we strengthen the existing capabilities and trigger the potential?

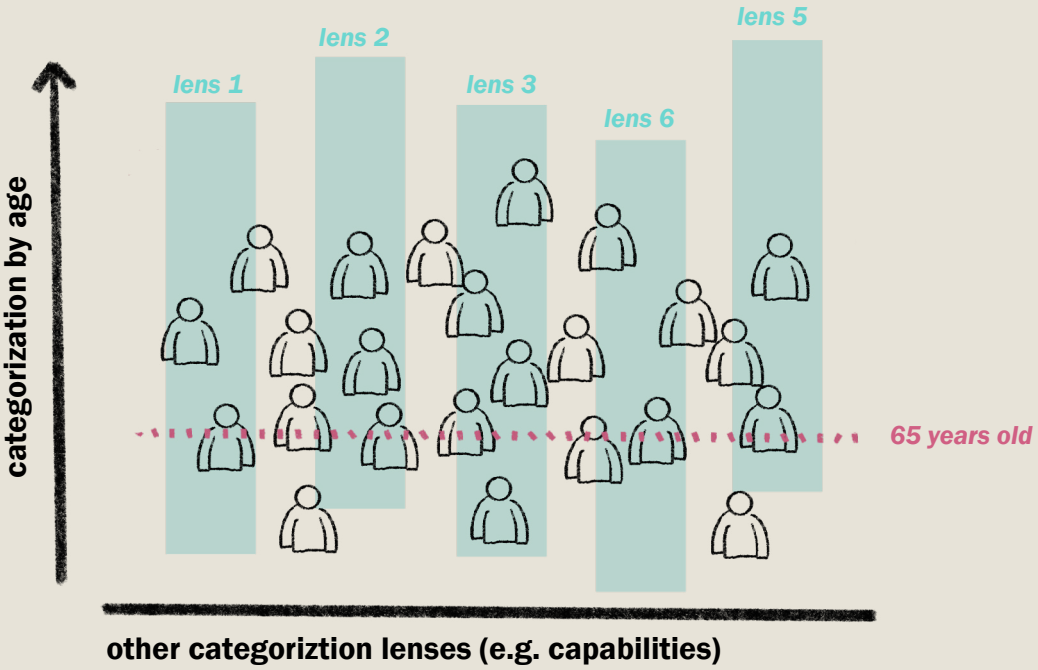


Figure 31 Illustration of different categorizing lenses

Problem Definition & Design Vision

PROBLEM FRAMING AND DESIGN VISION

This section consolidates the findings from previous chapters into a problem definition. It starts by converging the findings from previous chapters and then defines the design challenge and carves out the opportunity space. Then a design vision that specifies the design features is established.

Converging Findings

By synthesizing the insights from previous chapters, the author identified the discrepancy between the real aging process and the state-of-the-art of gerontechnology misled by the outdated narrative about old age/aging that should be challenged (Figure 32).

On the one hand, the literature research and empirical studies indicate that aging is a multi-faceted, dynamic, and deeply personal process. On the other hand, the current design of gerontechnology is prone to myths about aging at odds with reality which might lead to three types of pitfalls (chapter 1). This gap in-between calls for a reconceptualisation of old age and a paradigm shift on the design focus of gerontechnology. This poses new challenges as well as opens up the opportunity space for designers to tap into the potential of technology based on a holistic understanding of older people's real needs.

Figure 32 Design goal

Design Vision

The overarching goal of this project is to overturn the dominant but problematic rhetorics (see chapter 1) around the technology for older people. The starting point for this is to reconceptualize the notion of aging to reflect the rich lived experiences and to design for the personal and dynamic aging process. According to the research results so far, the envisioned design features can be summarized as **situated, empowering, and adaptable** (Figure 33).

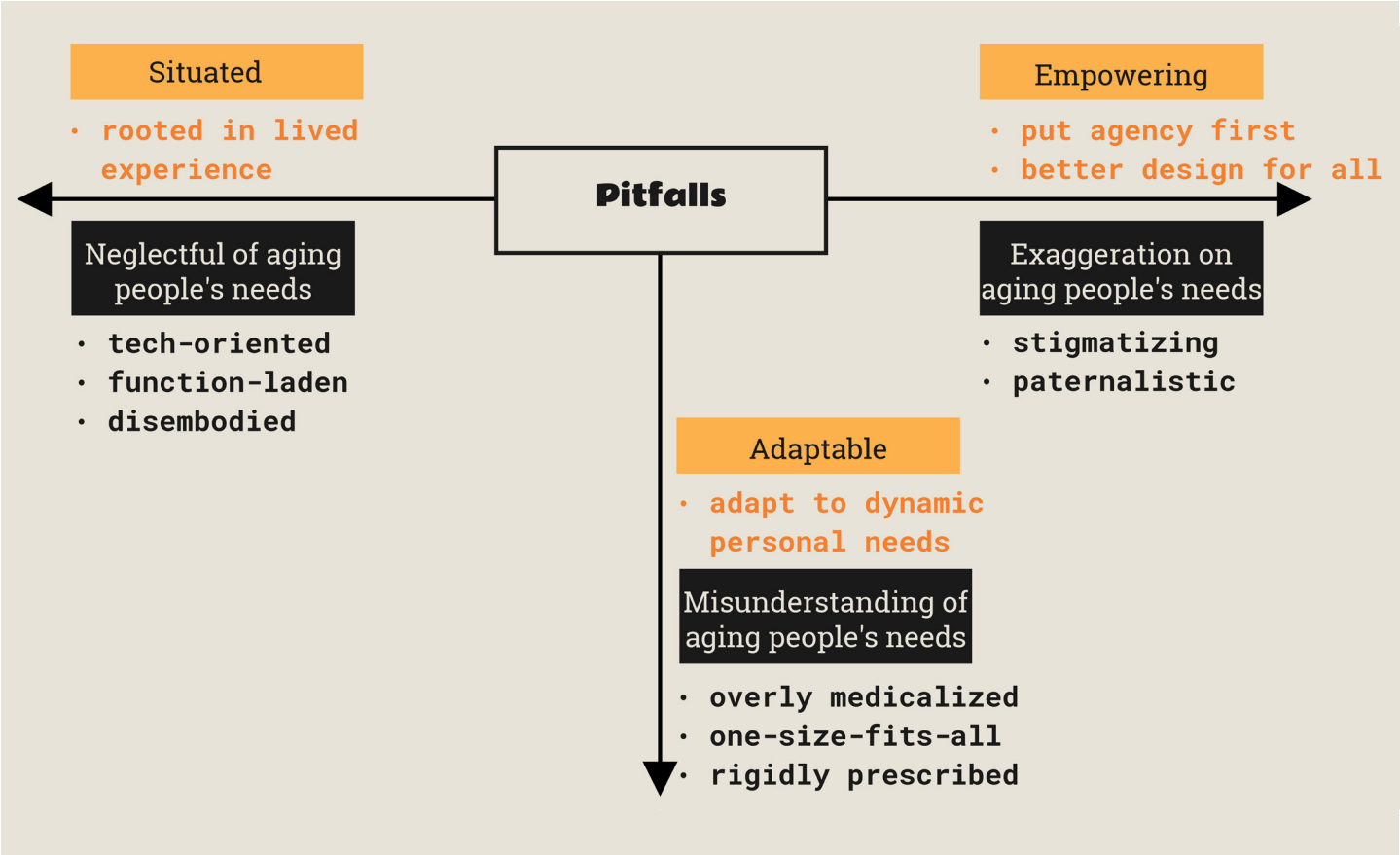
To avoid casting the shadow of stigma on technology for older people, the design should be carefully positioned and branded to advocate the autonomy thereby enhancing older people's self-efficacy and empowering them. To make sure the design won't go to another extreme of ignoring older people's needs, the design should be established upon the daily practices of older people. To answer the various personal needs emerging along with different individuals' aging process, the design needs to be able to be adapted or repurposed accordingly.

Accordingly, the design goal can be phases as follows:

How to design a product-service system (PSS) that can be effectively appropriated by older people in varied ways tailored by personal daily needs.

The multi-faceted, dynamic, and personal nature of the aging process seems to make it a formidable, if not impossible, task to design for it. It is no easy task to fulfill the design features stated above, especially for the adaptability. Nevertheless, what gives off the light of hope at the end of the dark tunnel is an approach that can be used to design for situated, everchanging day-to-day life: open design. The next chapter will elaborate on the meaning of open design and author's initial attempts of making design open to various use.

Figure 33 Design features



Prologue

PROLOGUE

Initial Concepts

After picturing the design vision elaborated before, I started ideating possible design concepts to give the shape of the design space. Here are the two initial concepts which later helped inform the set-up of a generative session with aging people.

Concept 1: Visual Finger

Visual finger (together with a virtual system) is a customized trigger-output system based on the logic of if-this-then-that (IFTTT) (Figure 34).

The whole system is based on an if-this-then-that (IFTTT) rule. The tangible part of this PSS provides the pre-set gestures or passively sensed information as the input.

The tangible product in this concept is an artificial limb - one extra finger that can be worn like a ring. The simulated biological form is intended to trigger a natural association of use like a finger. The movements or gestures could therefore be captured and recorded. The actively created gestures (e.g. tapping a surface) will be put in a library and serves as a set of triggers for certain functions. Embedded sensors - a micro camera - works as a life recorder and can be reconfigured as the input of certain functions. All data can be transmitted to a smart device installed with the application. Basic motor components - a vibrator and an LED - are integrated to provide visual and haptic feedback when certain triggers are met.

Possible use cases:

> *IF the finger is being pressed by the side*
> *THEN transmit the real-time image to the phone*

> *IF the finger detects abnormal movements*
> *THEN give long vibration feedback*

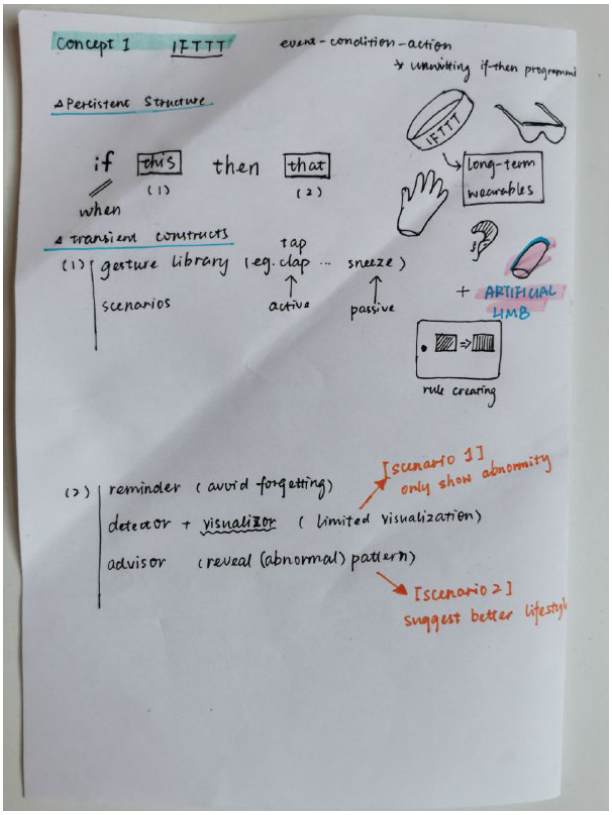


Figure 34 Concept 1 Visual Finger

IF not being stopped
THEN send emergency signal

Concept 2: Able Lifekit

The Able Lifekit is a hub of smart objects that take the form of ordinary everyday objects, for instance, clamps, hooks, pins, etc. Those objects are already highly dispersed in everyday life. The familiar form they have can easily inform the users of the potential way of use. The physical affordances provide the critical clues required for its proper operation. For example, to hang with a hook because it's hang-able, to clamp with a clamp because it's clamp-able, etc. In this sense, it's quite directional. But on the other hand, they are still open to reinterpretations because they can be associated with different objects and used in different contexts. For example, the hook can be used to hang a coat as well as a chain of keys. Digital functions - which are extra-ordinary to the original objects - like glowing, alarming, vibrating, timing, and sending signals can be embedded to make them smart.

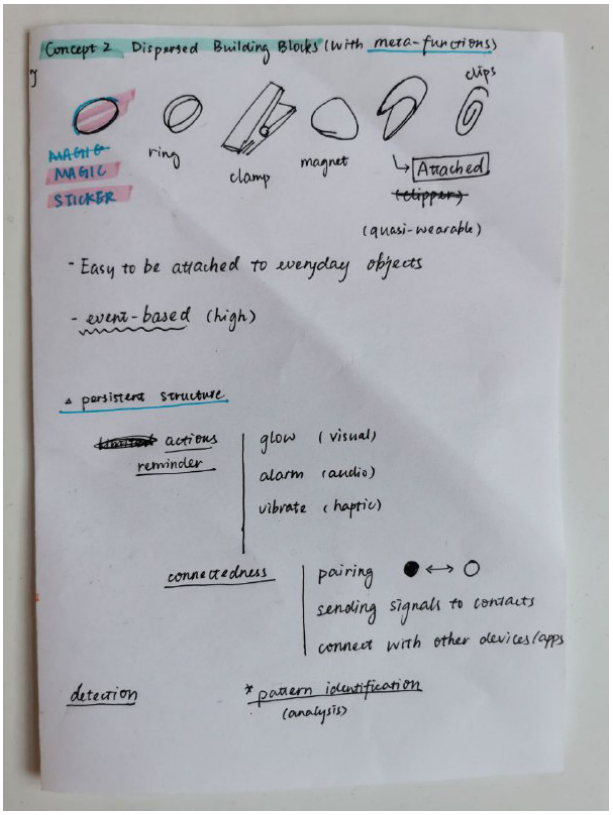


Figure 35 Concept 2 Able Lifekit (Sketch)

Reflection

Concept 1

Manifesting as an organic form, the visual finger serves as a fingery eye that can augment and extend users' perceptions thereby augmenting certain capabilities. It can do almost anything you can imagine a finger can do like poking, pressing, tapping, etc. As the number of gestures with fingers is enormous, it is highly customized and flexible which abounds with opportunities to configure. However, the customization process can be rather complicated to learn which increases the difficulty of use. Besides, though it provides the opportunity to create a personalized library of gestures, it can be a formidable task to remember all of them accurately, which accordingly increases the memory burden. Besides, the configuration of the rules heavily relies on extra devices like the smartphone, which to some extent restrict the exploration of the

visual finger if not configured properly. That being said, once the configuration has been done, the visual finger is still competent to work as a powerful product.

Concept 2

Taking the form of everyday objects, the Able Lifekit is easy to adopt at the first glance. As many of everyday objects are used in various daily activities, the extra-ordinary functionalities can be triggered to use in different contexts. This kit therefore naturally fits the context. While each one of the products in the kit can function separately, the interconnectivity among those products enables possible use in combination. The downside of this concept is that the familiar form of the thing (REFERENCE) - not an object anymore because it is embedded in a network - risks being so directional that it obstructs the exploration of 'unusual' ways of use.

Table 3 summarizes the comparison between the two concepts according to the reflection above. Obviously, the second concept outweighed the first one and was chosen to be the foundational concept for further development. Most noteworthy in the second concept is the use of existent everyday objects like clamps, magnets, etc. that are familiar to people. **The physical affordances can be the 'primer' to triggering natural early-stage use and guiding the exploration of the digital functions. This provides a potential way to steer the process of exploration.**

	Adaptable	Inviting	Embodied	Easy-to-adopt
Visual Finger	+/-	++	+++	---
Able Lifekit	+++	++	++	+++

Table 3 Comparison between two concepts

RELATED THEORIES

Explorations around design features mentioned in the previous chapter led me to the direction of 'design for openness'. Design for openness is a design approach that draws upon various design theories or frameworks including appropriation, open to interpretation, ambiguity in design, meta-design, and so on. Actually, there are many similar other theories or paradigms that have inspired this project including non-finito products (Seok et al., 2014), bricolage (Lanzara, 1999), , and so on. Due to the limit of space, I won't elaborate on all of them but mainly focus on the following four.

Ambiguity in Design (Gaver et al., 2003): instead of viewing ambiguity as anathema in Human Computer Interaction, Gaver et al. promoted ambiguity as a resource for design to encourage close personal engagement with systems.

Apprpriation (Dix, 2007): i.e., the process through which users interpret and apply technology in their own ways, potentially going against the intentions of the designers.

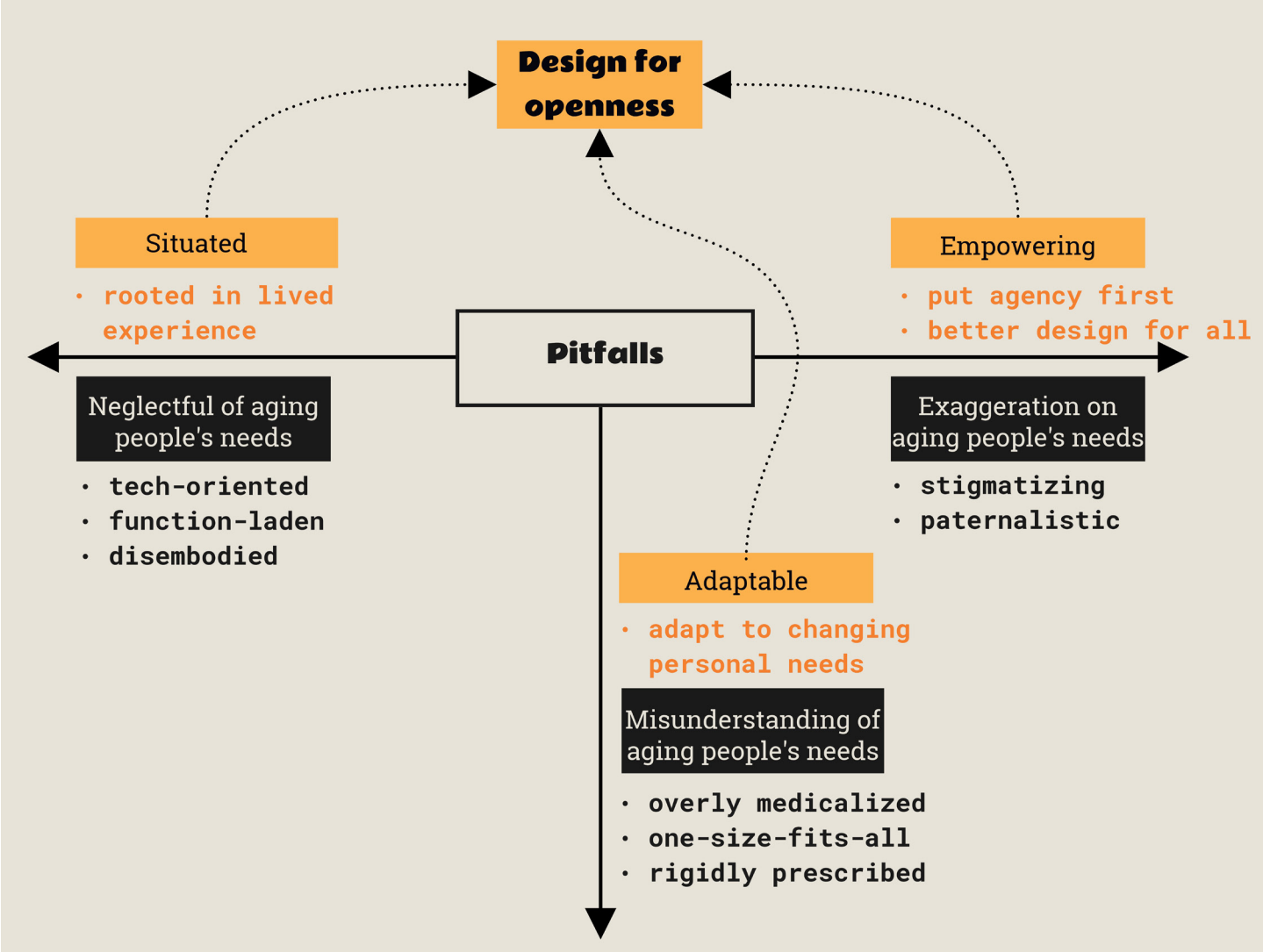
Meta-design (Fischer and Giaccardi, 2006): also known as 'design for designers', is a design paradigm that enables different stakeholders, including end users, to act as (co-)designers even during use time, blurring the distinction between designers and users.

End-user development (EUD) (Lieberman et al., 2006): a paradigm that emphasizes systems' capacity to provide support throughout application development, obfuscating the line between design time and run time.

These related theories promote various ways of use by embracing the uncertainty in design.

Three advantages are brought by the openness in design, which perfectly answer the design features brought forward before.

- First, situatedness – each use case is uniquely constructed in a certain situation.
- Second, dynamics – the openness of use purposes offers the potential to satiate changing needs over time.
- Third, autonomy – the purpose of use can be decided by users, which provides a feeling of control thereby enhancing the autonomy.



MAGIC INTRA-ACTION MODEL

After establishing the desired vision and ideating the initial concepts, I paused and took a reflection-on-action and tried to decompose the envisioned interaction. For a better and more accurate description, I will start by introducing the meaning of the name - Magic Intra-action Model. Then I will explain the three fundamental components within the model, which are human drives, physical affordances, and digital functions.

Background

Magic: driven by daily practices

What makes ordinary objects magical? David L. Rose (2014) at MIT Media Lab coined the word enchanted objects in his book Enchanted objects: Design, human desire, and the Internet of things. Disappointed by the fact that so many products are 'difficult to understand, frustrating to use, overwrought with features', he attempted to 'develop products that are engaging and essential, resonating with the latent needs of those who use them, and that creates an emotional connection with us human beings. Along this line, magic can be understood as the product's ability to answer humans' fundamental drives and bring an engaging experience perfectly. In this project, we use Nussbaum's capability theory (see chapter 3 prologue) to define the magic effect, which is the augmentation of a certain capability. Hence, the word magic lays stress on the fulfillment of persistent human needs and desires - magic emerges when the needs and artifacts are perfectly matched.

Any sufficie
advanced te
indistinguis

Intra-action: continuously configure and reconfigure

Drawing upon the Baradian theories (Karen Barad 2007), I borrowed the term intra-action to describe the continuous process of co-constitution between humans and machines. It is different from interaction by defining the primary ontological unit of reality as phenomena that include both people and things (Figure 36). The term intra-action strikes the bidirectional nature - it is not only us shaping smart things but also being shaped by them as well.

As Frauenberger (2021) pointed out, 'Taking a relational ontology perspective offers to describe our relationships with smart things as a process of defining and continuously redefining us and the smart thing through our intra-action. This reorientates designing smart things from the magic-like tool towards an actor with intent that needs to be open to negotiate its relationship in a wider network of use.'

We shape our tools and then the tools shape us.

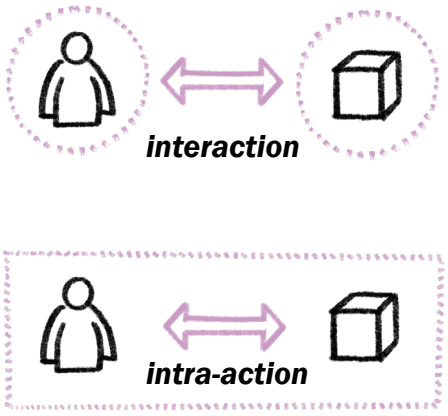


Figure 36 Interaction VS intra-action

ntly echnology is hable from magic.

Elements of Magic Intra-action

Inspired by the mutual constituency nature pointed out by entanglement theories mentioned above, the design of smart things should also be seen as infrastructuring (Star & Ruhleder, 1994) technologies within its socio-material and sociocultural context, and the infrastructured technologies can be interpreted and re-interpreted in different ways. Acknowledging the continuously shifting boundaries between humans and their smart things, how to craft the magic intra-action would be the next question. I attempted to identify the 'magic potion' ingredients. They serve as design handles in order to ground and craft the magic intra-action. They are human drives, physical affordances, and digital functions.

Desired Capability (Human Drive)

According to Robeyns (2012), a narrow usage of CA (capability approach) could be providing a proper conceptualization of individual well-being, namely in terms of the capabilities that a person has. Hence, the Within this project, the human drive is the fundamental need and desire stemming from daily life. They can be expressed from the capability approach perspective, as what capabilities are needed to strengthen.

Physical Affordance

The word affordance was first coined by Gibson (1979), who defined it as that 'what it offers the animal, what it provides or furnishes, either for good or ill. They are actionable properties.

Digital Function

The digital function is the crucial component to fulfilling the human drive. Its characteristics largely decide how much it can adapt to different situations.

Figure 38 shows the three main elements in the process of intra-action. It is a seed of the theoretical idea that later helped structure the co-speculation sessions

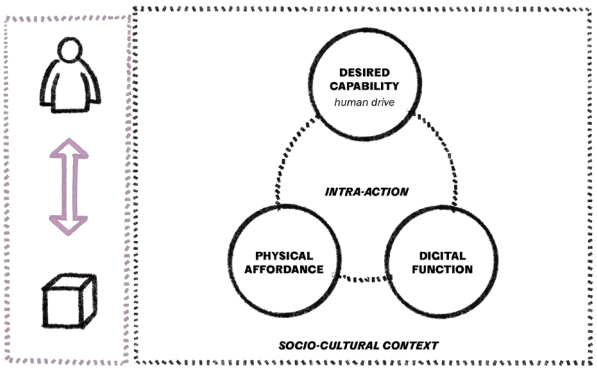


Figure 37 How the concept of intra-action informs the theoretical idea

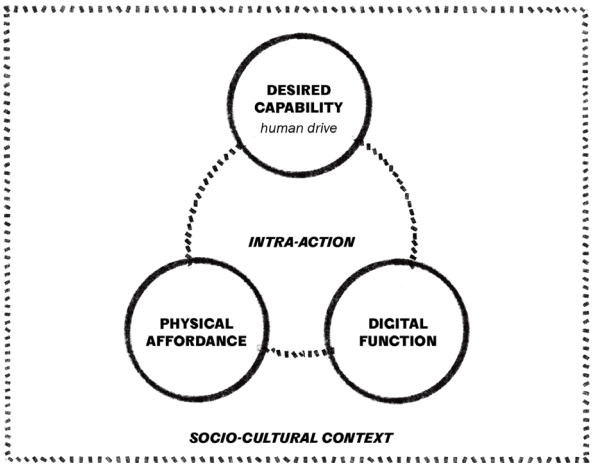


Figure 38 Three main components within intra-action

Magic Intra-action Formula

The relationship among these three components based on assumptions is described through a magic intra-action formula:

> *physical affordance(s) + digital function(s) <=> desired capability*

It was assumed that the desired interaction (intra-action) happening over time is instigated in a bidirectional way:

- (1) The set of physical affordances and digital functions might lead to a list of human capabilities where the artifact can strengthen;
- (2) The need or desire for strengthening certain capabilities in daily life might, in turn, trigger the appropriation of certain physical affordances or digital functions.

In this way, the interaction (intra-action) between the smart thing and the person is enriched over time.

Stimulus

Certain everyday objects arouses investigator's attention during the conceiving of the second concept and are later brought to the co-speculation session as the tangible stimulus. One example is a lens (Figure 39). It is different from the raw materials which it is made of (in this case, the glass) and is not quite a complete product such as glasses, binoculars, magnifiers, etc. This in-between feature makes it open for multiple interpretations. More similar objects selected to use in the co-speculative sessions will be shown in the next chapter.

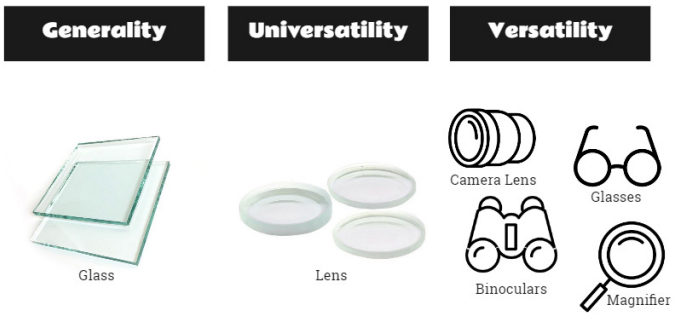


Figure 39 Lens as an ambiguous object

Takeaways

- The definition of design goal and the envisioned design features roughly carve out the desired solution space. Two initial concepts were loosely explored before settling on the direction of design for openness. Related theories were studied before the theorization of an itra-action model. Insights were taken to the next phase of co-creation with older people.

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Co-speculation Session

CO-SPECULATION SESSION

The co-speculative sessions conducted with aging participants aim to validate the intermediate knowledge obtained from previous research activities and gain new knowledge to inform the following design process. Findings and outcomes such as frequently-mentioned topics (capabilities), meta-objects, and the magic interaction formula from previous chapters were used to create the ideation materials to stimulate the participants. This chapter starts by providing background information about the expected outcomes of the sessions and the assumptions to be validated. Afterward, used methods and the detailed set-up of the sessions are introduced. Insights related to the assumptions are generalized and the emerging concepts from the workshop were translated into visuals by the investigator. Overall insights were extracted to feed into the development of the theoretical model

Background

Guided by the design vision stated in the previous chapter, several questions were to be explored:

- ***Physical affordance***

  Whether the providede materials are able to elicit certain bodily movements and how?

- ***Digital function***

  Whether the participants are able to spontaneously associate certain digital functions with the objects primed by bodily movements?

- ***Desired Capability***

  Whether the participants are able to recall their needs and desire to imagine the use scenarios of the objects with extra digital functions?

- ***Overall***

  How can the magical interaction formula (see Chapter 5) be completed by the participants?

If the completion of the formula was plain sailing, generalize the successful experience. If not, analyze the failure reasons.

Method

The objective of the session was to stimulate participants to actively interact with the provided objects with the body and then take the bodily experience to the phase of scenario ideation and function association. During this event, the method chosen was called co-speculation which is grounded mainly on speculative design and participatory design. This method turns the non-professionals into co-futurists and enables them to co-imagine the possible futures with the designer.

The investigator of this project bore an open mindset to the outcome of these experimental sessions. Whether proceeding smoothly or not, learnings from success or failures could be absorbed in the next phase.

Participant Recruitment

Four out of five participants who have been interviewed about one month before. They all have been invited to the session at the end of the last interview and four of them were able to attend while Emily was away on vacation so not being able to do so. The first interview provided a good opportunity to get to know the participants

personally and laid the foundation for this session.

Ethical Considerations

Permission for audio recording was obtained before the start of the session. Photos taken during the sessions were approved by the participants. Moreover, the project proposal and data management plan were reviewed and approved by the Human Research Ethics Committee (HREC) of TU Delft.

Procedure

The co-speculation session was conducted one-on-one at the same place as where the interview did: three were in the participants' places and one was at the cafe. Table 4 showed the detailed information of the sessions. (Table of participant, place) The sessions lasted about 90 minutes.

Opening

The participants were asked to give permission for audio recording. After that, the facilitator briefly introduced the main activities of the session and let the participant ask questions they have before officially starting.

First Activity (Warm-up)

The session started with a five-minute-body scan guided by a pre-recorded voice guidance on Calm. Calm is a popular application for meditation and sleep. The body scan was aimed at tuning into the body—to reconnect to the physical self—and notice any sensations you're feeling without judgment.

Second Activity

The participants were asked to play with provided objects freely. To encourage them to interact with the objects through the body, two heuristic questions were asked: (1) Can you wear/put it on different parts of your body? (2) How can you interact with it? Participants were encouraged to think of natural ways of embodied interactions and then come up with unfamiliar ways.

Participant Name	Gender	Place	Time (min)
John	Female	Home	124
Anna	Male	Home	86
Tina	Female	Home	97
Robert	Female	Cafe	102

Table 4 Information about the sessions

Third Activity

After exploring the objects for a while, the participants were introduced to a set of digital functions by the facilitator. Given that most aging people might not be familiar with digital functions, the functions were briefly explained. They serve as the inspiration pool that the participant could use for the later association.

The participants were asked to think of some activities they valued in their life. Activity cards created by the investigator were provided as inspirations. Starting with unpacking the sequential scenes in the activity, the participants were prompted to think of how to associate certain functions with the provided objects to support the activity. The speculation ended with enactment of the scenario with the object. Two to three rounds of speculation were conducted until the end of the session.

Ending

The sessions were closed with appreciation expressed by the investigator. Further questions from the participants were answered after finishing.

Data Collection

Object Stimuli

Several daily used objects were provided. They were elastic bands, belts, rings, lenses, magnets, ropes, gloves, stickers, beads, and clips. They were classified as the meta-objects mentioned before.

* Some extra materials were also provided in the pilot session to see the participant's responses.

Facilitating Cards

Accompanied by the objects, the following materials were used to guide and stimulate the imagination.

(a) Magic intra-action formula canvas: it was created based on the assumption in the previous chapter. What's worth noting, the original terms (desired capability, physical affordance, digital function) were deliberately replaced by the words (activity, object, function) that can be easily understood by the participant. For the session, it served as an overview of the whole session and was shown to the participant in the beginning.

(b) Digital function card set: it was an unexhausted list of digital functions brainstormed by the investigator. There are 48 cards in total.

(c) Activity card set: it was a set of activities created based on the result of the previous interview. The most frequently mentioned topics were included to develop the related activities. There are 12 cards on 4 topics.

(d) Instruction cards: the most important instructions for each activity were printed out on the cards to make it easier for the participants to follow.

(e) Facilitator's sheet.

Figure 41 shows the cards in use.

Along with the materials for stimulation, participants were encouraged to think out loud along the whole

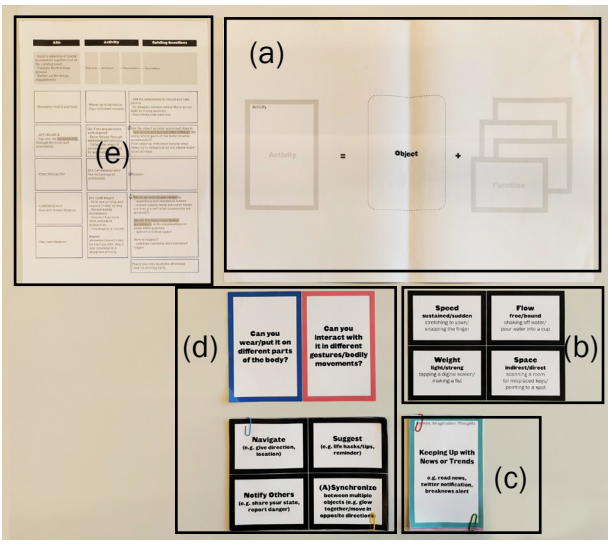


Figure 40 Facilitating cards

(a) Magic intra-action formula canvas in A3

(b) Digital function card set

(c) Activity card set

(d) Instruction cards

(e) Facilitator's sheet.

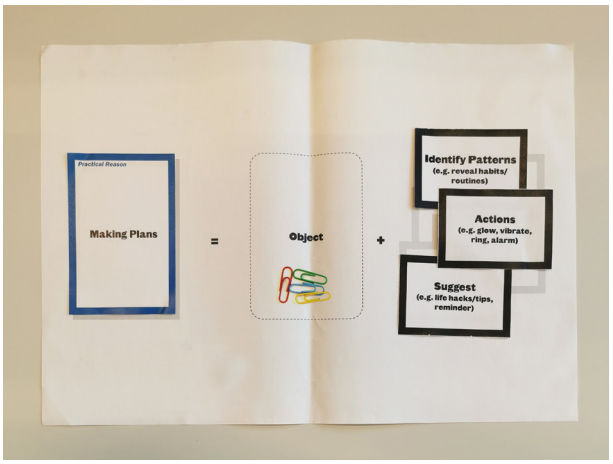


Figure 41 The materials in use

process and were assured that there was no right or wrong in what they said thereby ensuring their freedom to imagine. The facilitator might give necessary guidance or intervention when the participants got stuck or deviated from the instruction. Extra photos were taken during the process when necessary.

Data Analysis

The analysis was conducted in three cycles. The first cycle was to review the recording and focus on answering the questions listed at the beginning of this chapter. The second cycle concentrated on translating the imaginary scenarios mentioned in the workshop into visuals to better show the concepts. Finally, the last cycle was to revisit all materials including audio recording, notes taken by the investigator, and photos, and extract observations that inspired the researcher.

Findings

Insights on Assumptions

On physical affordances:

Figurative associations are easier to elicit than bodily movements.

It was noticed that when asked to play with the provided objects and explore with their bodies, the participants were difficult to quickly think of different bodily movements. That meant the objects were only able to elicit limited bodily movements. One reason might be that the most intuitive and natural bodily movements elicited by the object are limited (e.g. Stretch the elastic band, Thread through the beads). When encouraged to explore unfamiliar ways of interaction, some participants might even feel awkward.

> *I will never stick it [sticker] to my body. [Robert]*

This means that It is not an inborn ability to generate rich body language. We can also say everybody has different levels of somaesthetic literacy. Professional dancers probably have a larger bodily vocabulary than average people, let alone aging people who might face a decline in motor skills.

Though the elicitation of bodily movements is harder than expected, another type of association was quite remarkable, which is the association of doings including related practices and situated actions. Another noteworthy type of association was attaching cultural or metaphoric meanings to the object. For example, Anna associated the sticker sticking beneath the desk legs or chair legs to prevent scratching with the environmental orderliness and inner tranquility. Robert

associated lens with observation and discovery. Table 5 shows a few examples.

Object	Associations
Clip	paperwork, reminding, orderliness ...
Magnet	direction, navigation, secured ...
Ring	symbol, stamp, identity, heritage ...
Lens	observation and discovery ...
Sticker	environmental orderliness and inner tranquility

Table 5 Objects and corresponding associations

Implication\ Tapping into the broader range of doings instead of imposing unnatural bodily movements as the trigger.

On digital functions:

The pairing of functionalities and objects is difficult.

After the participants were introduced to the functions, activity cards were provided. The task to associate certain digital functions with the provided objects they previously explored was quite difficult. The effect of the first exploring activity being used as the input to pair objects with functions was limited. This implied that drawing connections between the physical affordances and digital functions does not make much sense. One possible reason is that when requested to pair the object and the digital functions from scratch, too many options lead to difficulty in meaningful pairing. This also indicated that the DIY rule configuration in the first concept does not suit them - the operation is too complex to use.

Implication\ Design professionals decide the pairing functionalities with the objects instead of leaving them open to the user.

On desired capabilities:

Not all needs or desires can be enumerated purely in mind.

When asked to imagine what they needed to support the activities they valued, many participants got stuck. One possible reason is that the overwhelming information was hard to process. Besides, more importantly, this implies that the emergence of needs takes time. Because of the limited time of the session, the whole session is arranged to simulate the process of appropriating ambiguous objects in everyday settings instead of the real one. However, it's apparently hard to condense the process which might take weeks or even months into a 90-minute session. Creative use of ambiguous objects can only be triggered by genuine needs or being revealed to serendipitous functions.

Implication\ Participants need to be continuously guided and provoked by reliving the experience and activities to complete enactment.

Emerging Themes

The following shows the topics emerging and catching the investigator's eyes during analysis:

Unexpected Affordances

Even the perceived affordances might be different from what the designer expects. During the pilot session, the participant was provided with a piece of reflective paper. The reflective feature was assumed to stand out most by the investigator. Surprisingly, the first response from the participant was to scoop with the paper to help him pick up the small objects on the smooth surface, which is hard for him to pick up by hand (Figure 42). This indicated that the perceived affordances of the object might misalign with what is intended by the designer.

Decoupled Functions and Multistability

At the end of the session with Tina, the stove beeped and Tina immediately went into the kitchen to turn it off. 'It was the 90-minute,' she explained. This left a deep impression on the investigator. Even though the stove is usually to be used for cooking, Tina was able to decouple one function - timing - from the object and intentionally use it. As illustrated by the highly influential example of a hammer put forward by Heidegger (1996), a tool is 'something in order to and a tool does not exist by itself, but in the context to which it refers. For instance, the stove is a cook used to provide heat during cooking while it is a timer used for timing in the situation mentioned before. This was exactly one example of the multistability of objects appropriated deliberately by the user.

Figure 42 Unexpected use

Autonomy and Shame

During the discussion about mental health, Anna compared the experience of going to see a psychological therapist with that of talking to a smart agent.

> *It's also a kind of autonomy. It's not like going to a doctor, saying, you are gonna feel really miserable and you feel like an idiot ... saying that you feel ashamed for yourself. There is no shame in magnets. [Anna]*

This implies that inanimate agents provide security and the sense of security to confide in. Whether she would feel scared to use robots in her life was asked as a follow-up question.

> *I mean if somebody brought me a robot, I would give it a name. [Anna]*

She said that she understood what makes people concerned is their life being taken over by artificial intelligence but she knew it was not the present. She noticed that the robot or smart agents are not

infallible. The fallibility reassures her that she is still cleverer.

> *The decision ultimately is mine. I am the one who decides whether it's right or wrong. I always have the choice to opt-out. It is not scary for me. [Anna]*

Though she admits that fallibility can be a kind of reassurance for her, it is not always good to make mistakes. When it comes to a matter of life and death, it shouldn't make a single mistake.

Categorization and Openness

Another interesting observation from the sessions was two different responses elicited by the same object - the sticker. In the first case, the participant was familiar with the intended use of the object and when encouraged to explore how to interact with it even in an unfamiliar way, he stated,

> *I know they're for chairs ... I will never attach this kind of thing on my body. [Robert]*

While in another session, the participant didn't know what the object was used for and could only infer from its physical affordances. He commented,

> *It gives me a sci-fi feeling ... seems to be able to measure something efficiently. [John]*

It was fascinating to see how different categorization of the object influences the degree of openness to interpretation. The first participant immediately categorized the object into household tools and refused to go beyond the normative ways of use. While the second participant was aroused by the shape and materials of the object, and even stuck it to the forehead to enact a kind of smart device that can monitor bodily measurements. Again, as demonstrated by the hammer example, tools call attention to themselves when the reliable dealings we are accustomed to having with them are disrupted, as does the hammer when its head flies off the handle. The fixated categorization of the objects exerts invisible normative pressure to use it as intended and might undermine the ability of reinterpretation.

Willingness to Use

The style of the objects very much influences people's motivation to interact with them. The style should pique the interest of interacting even though the purpose remains opaque.

The style could be the composition of color, for instance, the brightness, the contrast degree, etc. It can have an emotional impact on users as well.

> *Vivid and bright colors make me pleasant and creative. [John]*

The archaic sense of the object might also influence the perceptions. The rope, which has been existing for thousands of years, manifests as an ancient tool and exhibits a sense of security to use and explore.

Emerging Concepts

Concept 1: Information Magnifier

Tina loves reading about botany. She is fascinated by different types of plants and always wants to know more about the plant she encountered in the picture or on the road. The magnifier not only serves as a tool to zoom into the details physically, but also helps delve into the information digitally as well.

One similar concept was also brought up by Anna. She mentioned using a lens to check the photography works closely and get associative information through it.

> *It is a way to renew yourself with knowledge. [Anna]*
>
> *Keeping up with the trend makes me feel young. [Emily]*

This concept was ideated to satiate the need of retrieving related information about the topic of interest. It helps strengthen the capability of senses, thoughts, and imagination.

John also envisioned a type of magnifier through which he could easily check the ingredient information on the food package and tell him whether it is healthy for him. He has type 2 diabetes and has to pay close attention to the sugar amount. He also keeps an eye on the nutrients. In this way, the tool can save him a lot of time checking the ingredient table. This concept helps strengthen the capability of body health.

Concept 2: Chatting Sticker

Anna noticed that loneliness has been a prevailing problem for aging people. Good social interactions and connections are important to well-being. She

Figure 43 Information magnifier

shared her observation on the people living in her building.

'This is a building with many aging people living here. And I can tell that many of them are lonely. Some because of the death of their old friends - this happens all the time for people our age and some are not able to make new friends.'

So the co-speculation result is a pair of magnets that can glow when detecting the movement of the other magnet remotely. Especially during the time of lockdown, many people live in solitude and this can be used to overcome isolation and separation. Besides, the action of glowing is a subtle signal of availability which is quite different from the direct request to have a zoom meeting. This increases the capability of emotion. As put by Anna,

> *... if you say 'can we zoom', the other person often feels this is not a great moment but I guess we can. As opposed to 'My friend is having a cup of tea, so am I, let's chat! [Anna]*

Moreover, it can also be used to detect abnormalities and integrated with an emergency

system. Anna said there were some people who died and hadn't been found for several months afterward. She shared another story,

> *There were two people living in this building, one called Peter and another man called Thomas. And when Peter moved in, they hated each other. But later they became friends. Thomas is not in very good health. For a very long time, Peter would phone Thomas at 8 o'clock each morning to see if he is OK. And a few days ago, Peter didn't phone. Fortunately, Thomas had a friend who is very fit and the friend managed to climb from one balcony to the other and to look through the window. And Peter was on the ground, he had had a stroke. ...it was intended in the other way around that Thomas is not in good health and Peter made the call to check if he is Ok and if not Peter would be the one phoning the ambulance. [Anna]*

So she imagined that the sticker might be able to detect the falling or sense the stillness of the person for an abnormal period of time and set off an alarm. If the person concerned doesn't switch it off after a while, the emergency system will be engaged. This concept mainly contributes to the capability of life and bodily health.

Concept 3: Magnetic Planner

For the sake of her profession (photographer),

Figure 44 Chatting Sticker

Anna needs to travel frequently. She imagined a set of magnetic cubes that can be used for planning. They can work as ordinary magnets attached to a huge board for making serious plans. This helps improve the capability of practical reasons.

She also got inspired by the potential of different sequential combinations of the cubes and imagined that they can give some random unexpected plans while shuffled to create a serendipitous experience.

> *It can suggest you go to a cafe or a particular landmark and you are going to meet somebody. But it is a random thing and it could be rather interesting ... It's an adventure. On the one hand, it could be intimidating. On the other hand, when you are surrounded by people who don't know you, it is also liberating... It could be something psychologically empowering. [Anna]*

Besides, different levels of significance can be ascribed to the cubes. They can be moved around on the board showing different planning structures as well as randomized for coming up with a surprising plan. This concept could help strengthen the capability of play.

Concept 4: Tangible News Filter

Another concept related to the cubes was come up with by John, who is a heavy news reader. He thinks it is important to stay relevant to the present society and he likes to follow the trends of his favorite bands. He subscribed to two newspapers and he didn't read them all but picked out certain types of news to read. Similarly, he

imagined the cubes could be a tangible news filter. He ascribed different types of news to cubes with different colors. By picking out some cubes and putting them in a particular order, he could easily orchestrate the news meal of that day. Random mode is also applicable. This concept helps strengthen the capability of senses, imagination, and thoughts.

Anna also mentioned associating the mood monitor with the news. The filter would suggest news composition based on the mood. For example, if the mood is low then lessen the dose of bad news.

Concept 5: Time-space Traveler Binoculars

Inspired by the street view of the Google map, Anna imagined a type of binoculars in which she could experience the real-time street view all over the world or travel back to the past to experience the urban landscapes of different places.

> *Maybe I can see what is going on in Manhattan right now or take a walk in Paris or experience the 16th century of England. That would be amazing. [Anna]*

This concept provides a stimulating experience and helps augment the capability to play.

Discussion

The co-speculation sessions with aging people were not plain sailing. Different personalities of the aging people make the facilitation of each session a new adventure. For example, some participants are more talkative and diverging and necessary interventions are needed to steer the direction of diverging. Some participants are more thoughtful and better at abstract thinking, some guidance toward concretized speculation is needed. Overall, it was a great pleasure to co-speculate and discuss with a variety of people. The discussion sometimes went surprisingly deeper than expected. The outcome of the sessions was full of surprises and effectively exposed the blind spots the investigator had. Besides, topics on autonomy and agency, chronological evolution of use, technology-utopian, etc. were touched upon during the sessions, which turned out to be quite inspiring.

Situated elderliness

One recurring pattern in the sessions with the aging people was that they would be positive about the value of gerontechnology, but then hurry to add that they themselves would not need something like that yet (i.e. it was useful for *other* aging, with more health issues)

Risks of Open Design

The synthesized findings also reveal the potential downsides of leaving the design completely open: **ineffective appropriation caused by misalignment between the use and design**. Let's first start with showing what the two different perspectives look like before diving into the risk of ineffective appropriation.

The perspective of design is oftentimes taken by professional designers, which involves manipulation with components from the object side mainly including selecting and prioritizing a certain set of physical affordances and digital functions over others to craft the artifact to satiate the drive to strengthen certain capabilities (Figure 45). In this project, the goal is to support the well-being of older people during aging-in-place by providing PSS that can be appropriated in various ways tailored to daily needs.

The perspective of use (Figure 46) starts with the desired capabilities/human drive. Artifacts are merely seen as the means of attaining certain ends. There is no so-called proper ways of use. As long as the ends can be attained, it is the proper way, unless the designer strongly imposed or nudged so (i.e. exerting normative pressure).

So, how can the misalignment between design and use happen and why should we be wary of it?

Usually, the misalignment happens when the the actual use of the design is different from designers' expectations (Figure 47). But wait, isn't the whole point of open design is to encourage and accommodate the possible different ways of use? Now why should we be concerned about the actual ways of use being different from what's expected? Indeed, the core of open design is to leave the design open to various ways of use

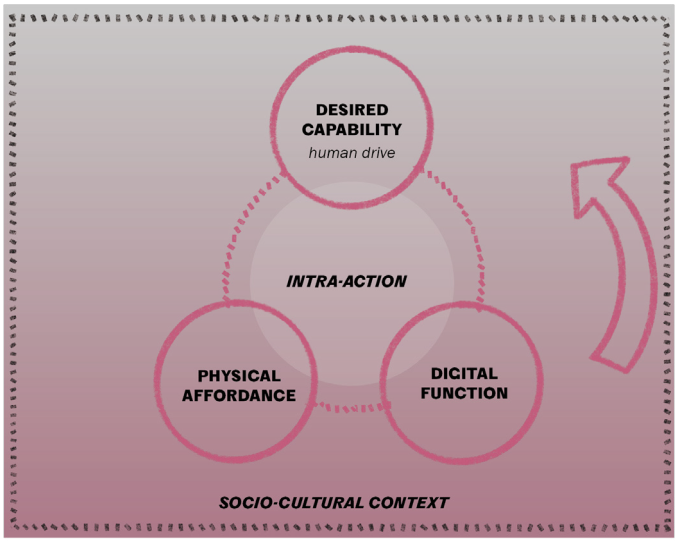


Figure 45 The perspective of design

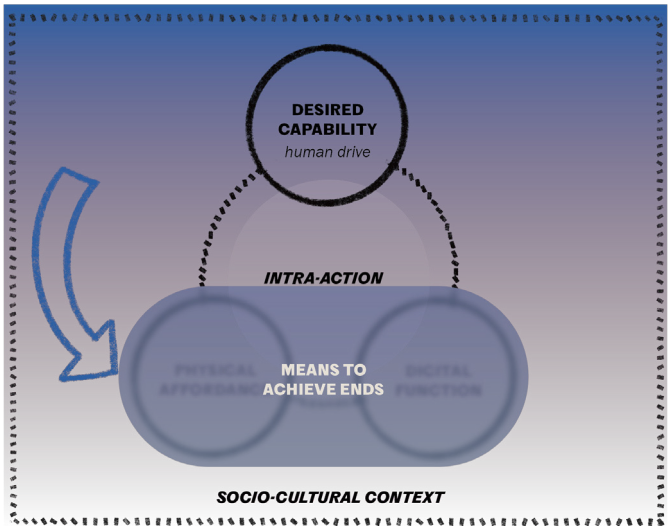


Figure 46 The perspective of use

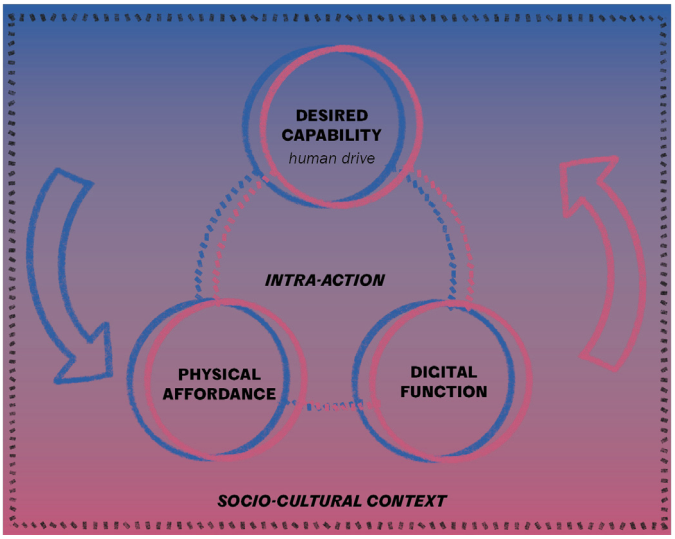


Figure 47 The misalignment of two perspectives

**The shades of color in the background indicate the degree of control. Designers have more control on the object side which is indicated by the darker pink shade at the bottom. Usera are the sources of human drives which is illustrated by the darker purple shade on the top.*

according to different individuals' daily needs. However, what is proposed to avoid here is ineffective ways of use. For instance, a piece of paper can certainly be repurposed as a knife by using the sharp edge, but it's far from effective ways of use like using it to take notes or fold it into an origami capsule to collect paper clips. Here, the ineffective appropriation is what should be avoided.

Therefore, instead of leaving the design completely open, certain design efforts should be put into providing enough use cues to lower the misalignment of use and design thereby improving use efficiency.

In the most extreme case, the misalignment might even cause the loss of usefulness. For example, the set-up of the workshop was an experiment to turn the participants into designers to decide upon the combination of certain physical affordances and digital functions according to the drives stemming from their daily lives. Though the researcher attempted to simplify the process by translating the 'physical affordances' into the choosing of the provided objects and substituting the abstract 'drives' into valued activities, the participants still had great difficulty in pairing the objects and the functions according to their needs. The difficulties encountered during this process indicate that it is usually counter-intuitive to force the users to customize the smart things from the perspective of design. Theoretically, there are so many combinations that the participants can make to suit a great deal of different needs and it should be super useful to cope with different situations. Practically, however, the complete freedom of customization engenders enormous complexity in actual use which leads to a sheer drop in usefulness. This paradox can be well summarized by the 'problem of level of tools' put forward by Don Norman (1986).

> *A major issue in the development of tools is to determine the proper level. Tools that are too primitive, no matter how much their power, are dlflcult to work with. The primitive commands of a Turing machine are of sufficient power to do any task doable on a computer, but who would ever want to program any real task with them? Most people need higher-level tools, tools where the components are already closely matched to the task. On the other hand, tools that are at too high a level are too specialized. An apple-peeler is well matched to its purpose, but it has a restricted set of uses. Spelling checkers are powerful tools, but of little aid outside their domain. Specialized tools are invaluable when they match the level and intentions of the user, frustrating when they do not. (Norman 1986)*

In this case, to leave both physical affordances and digital functions open is on a too primitive level to easily work with.

How to maintain the openness of design on a level that is effective for users to use? The design principles for designers to lower the misalignment between these two perspectives while still remaining open to a variety of use will be discussed in the next chapter.

Discussion

The co-speculation sessions with older people were not plain sailing. The different personalities of older people make the facilitation of each session a new adventure. For example, some participants are more talkative and diverging and necessary interventions are needed to steer the direction of diverging. Some participants are more thoughtful and better at abstract thinking, some guidance toward concretized speculation is needed. Overall, it was a great pleasure to co-speculate and discuss with a variety of people. The discussion sometimes went surprisingly deeper than expected. The outcome of the sessions was full of surprises and effectively exposed the blind spots the investigator had. Besides, topics on autonomy and agency, chronological evolution of use, technology-utopian, etc. were touched upon during the sessions, which were quite inspiring and brought much intellectual pleasure.

One recurring pattern in the sessions with the older people was that they would be positive about the value of gerontechnology, but then hurry to add that they themselves would not need something like that yet (i.e. it was useful for *other* older people, with more health issues). This might tbe partly true in this case, because many of the participants are in good condition. But sometimes, it might be that participants don't feel comfortable to talk about their own issues openly. This can be an obstacle in co-speculation if they were asked to ideate solutions for themselves. Hence, situated elderliness was used to detach the participants from their own experience. Activity cards were used as provided situations which are not necessary to be their own experience. In this way, participants will have no scruple to brainstorm and co-speculate.

Takeaways

- The findings from the co-speculation sessions reveal the potential risk of leaving the design completely open: ineffective appropriation which includes inefficient use and failure of adoption. How to maintain the openness of design on a level that is effective for users to use? To lower the misalignment between these two perspectives while still remaining open to a variety of use, I propose an iterated strategy. Several design protocols for designers will be discussed in the next chapter.

Concept Artifact

CONCEPT ARTIFACT

We identified the elements of intra-action in chapter 5 and the insights gleaned from the co-speculation sessions indicate that there might be a misalignment between the perspective of use and the perspective of design (see Chapter 5). The perspective of design puts stress on crafting the means to achieve certain capabilities by making an intentional combination between the exhibited physical affordances and digital functions. The perspective of use is triggered by human drives/ ends of achieving certain capabilities and drives the search for readily available artifacts to attain the ends. A concept artifact is crafted as a tangible manifestation of the proposed design strategy to lower such misalignment. This chapter will show the design process of the concept artifact.

Design Orientation

During this phase, new findings stemming from the co-speculation sessions are synthesized to navigate the design direction. Accordingly, the design requirements are reformulated to inform the next step of conceptualization.

Based on the first finding from the co-speculation sessions, I decided to tap into the rich meaning associated with ordinary everyday objects to lower the threshold of use. In the adoption phase, the familiarity of the object can evoke their past experience to provide an easy entry point of use and encourage them to explore the digital functions. In the post-adoption phase, the users gradually become familiar with the digital functions and begin to put the object in different use scenarios triggered by their daily situation thereby developing their own ways of use. In this way, the tangible parts of the product-service system serve as a bridge to connect abstract digital functions.

To achieve the above-mentioned developing process, I supplemented the design features with elaborated design requirements.

Situated

The designed artifact should resemble an ordinary everyday object that older people use frequently in their daily life.

The appearance of the designed artifact should effectively elicit the associated meanings inherent in physicality or conventions rooted in their lived experience.

The designed artifact should easily and naturally fit into older people's lives.

Adaptable

The digital functions of the designed artifact should be open to various purposes of use in different situations.

The digital functions of the designed artifacts should be simple yet effective, without complex or arbitrary configurations.

Empowering

The appearance of the designed artifact should be non-stigmatized.

The aesthetic of the design should elicit a strong willingness to adopt and explore.

Design Process

Hack a Clamp

I used one common everyday object — clamp — as the starting point, as it already showed rich associated meanings during previous sessions.

In 1853 David M. Smith of Springfield, Vermont invented a clothespin with two prongs connected by a fulcrum, plus a spring (Figure 48) .

I first explore the structure of clamps and identified that though there are many variations of clamps, they all share two essential elements: a wedge-shaped space between two prongs and resistance force provided by either spring or other materials. Variations of clamps can be classified by whether the two prongs are parallel and the direction of the resistance force (Figure 49). I finally chose type 1 as the final structure to develop the concept artifact.

Clamp UI

In the iteration phase, I tried different dimensions, and structures through sketches (Figure 50) and modeling (Figure 51). I also experimented with different compositions in the user interface. The design rationale behind the iteration process is based on careful considerations for ergonomics, conceptual models, signifiers, usability, and so on. Detailed reasoning behind iterations is illustrated in Figure 52.

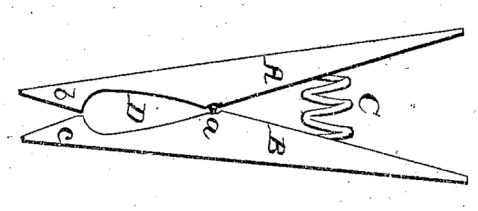


Figure 48 the clothspin invented by David

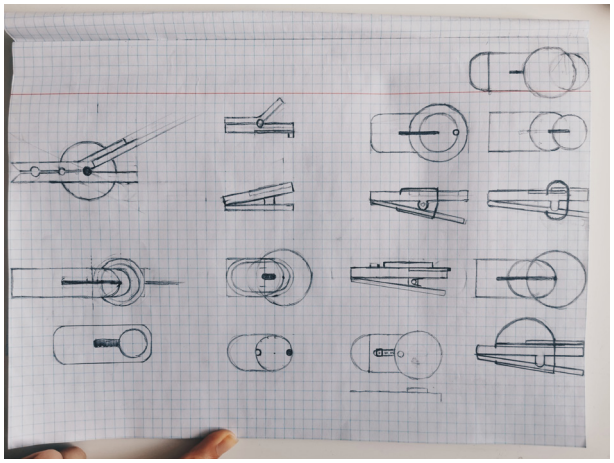


Figure 50 Sketches

Figure 51 Model

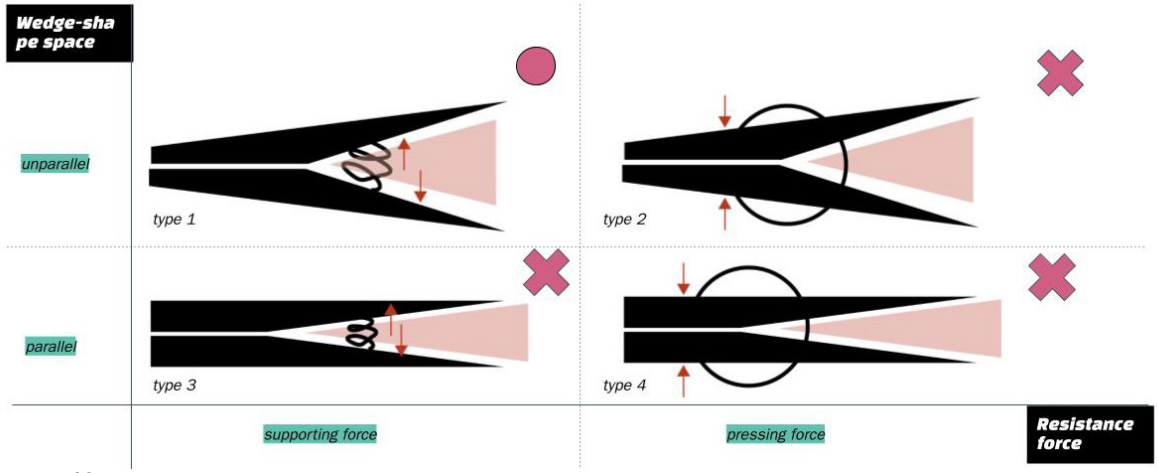
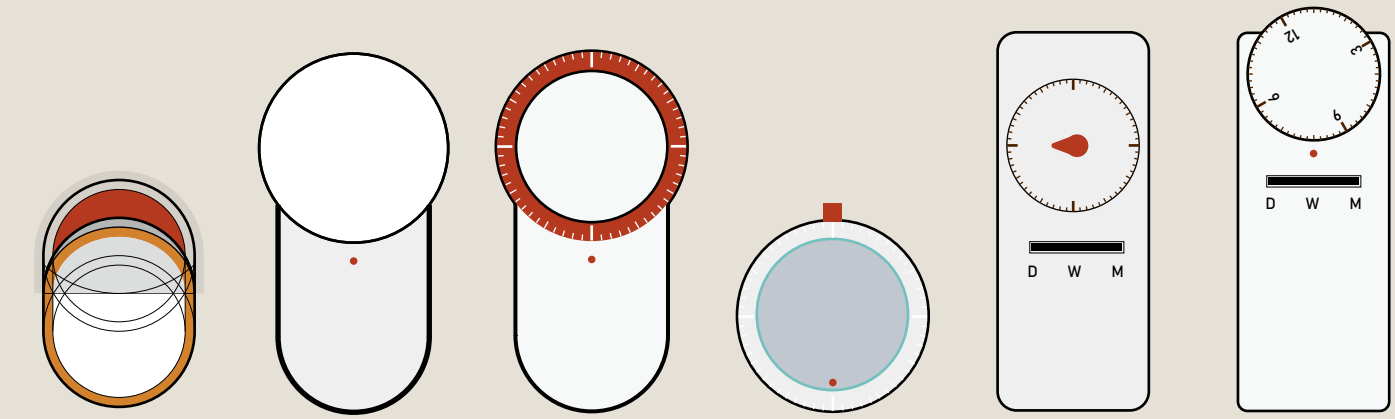


Figure 49 Hack a clamp

Clamp UI



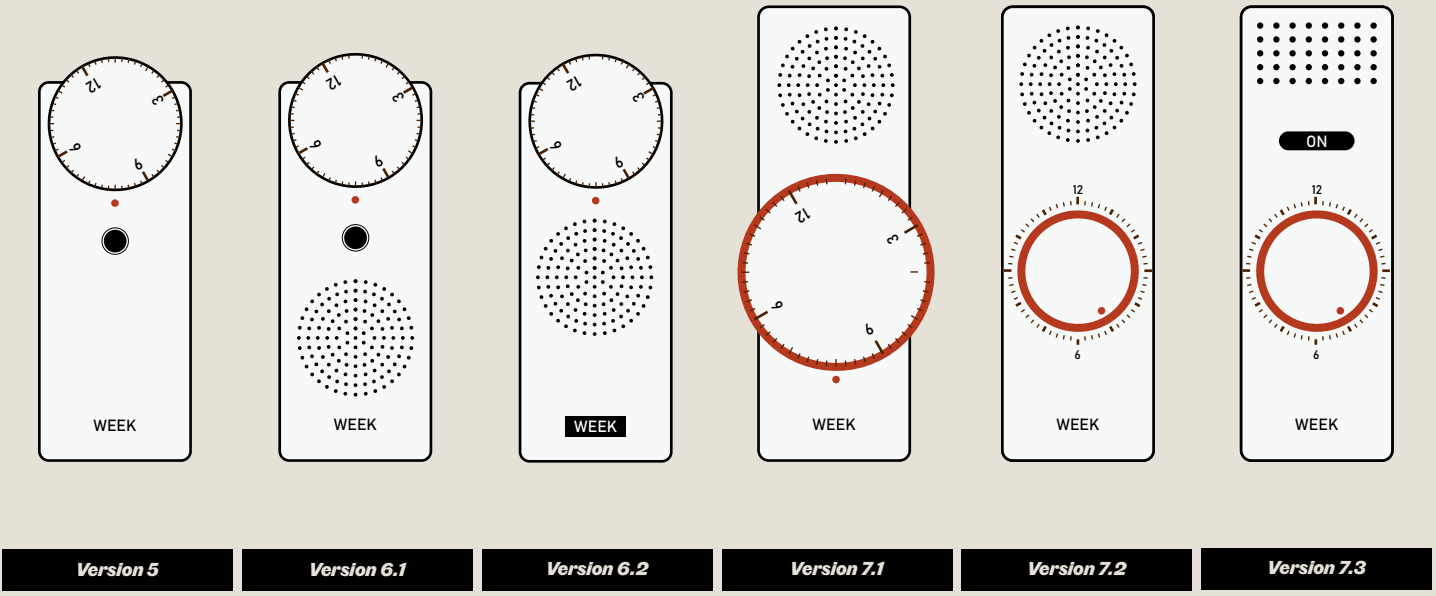
Version 1 | Version 2.1 | Version 2.2 | Version 2.3 | Version 3 | Version 4

From Version 1 to Version 2

- Decide to use unparallel prongs
- Use a round dial to input numbers ranging from 1 to 12
- Use the mental model of a stopwatch
- Experiment with different sizes

From Version 2 to Version 4

- Modify the shape of the front side from a round to a rounded rectangle
- The first try of adding the options for different time units (day/week/month)
- Make the time unit control a scrollable wheel
- Experiment with different forms of a dial (marks on the wheel/surrounding the wheel/using a pointer) keeping legibility and operating movements in mind



From Version 4 to Version 6

- Decide to distribute different timespans to different clamps (one clamp only has one type of time unit, and a clamp trio works as a set to lower the functional complexity)
- Try to use different sizes as indicators for different time spans
- Add a day/week/month mark
- Add the place for the speaker on the interface
- Add a button to turn on the timer

From Version 6 to Version 7

- Experiment different layouts
- Move the dial knob to the middle (to avoid misoperations while clamping)
- Experiment with different sizes of the dial
- Use a knob surrounded by numbers
- Remove the switch but finally add it as a backup (once tuning the dial it will be switched on automatically and will be kept on unless being manually turned off)

Figure 52 Iteration of the clamp UI

Final Design

The final design of the artifact is a timing clamp embedded with a speaker and a light. How it works is shown in a demo video (Figure 55). The application on the phone can control the clamps remotely. To be more specific, the application on the phone can switch on/off the clamp and control the light and sound of the clamp remotely (Figure 56). Besides, users can also find a specific clamp by using the AR Find function on the application (Figure 57).

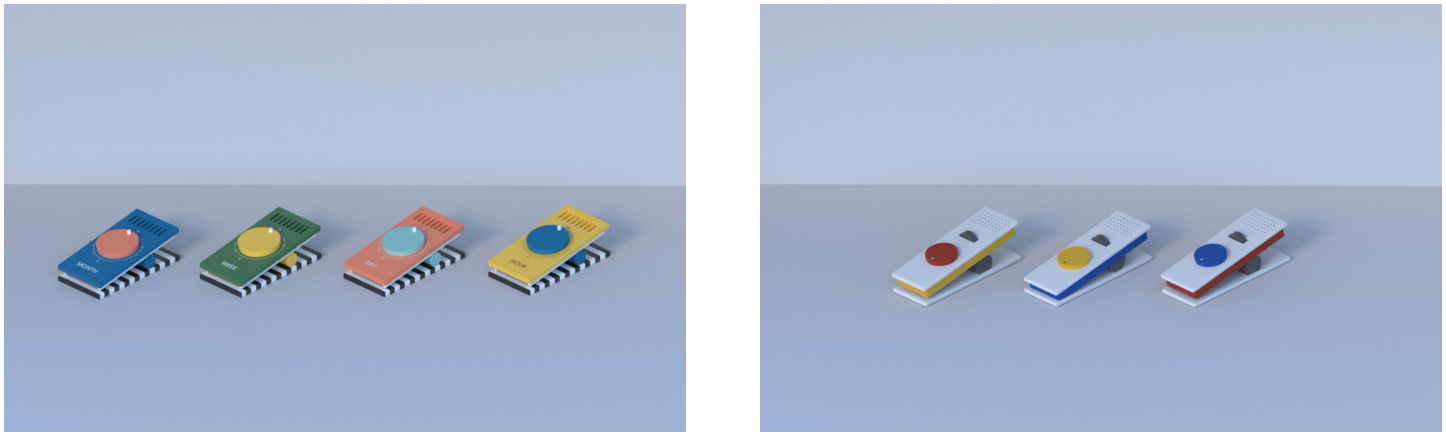


Figure 53 Experiment with different styles

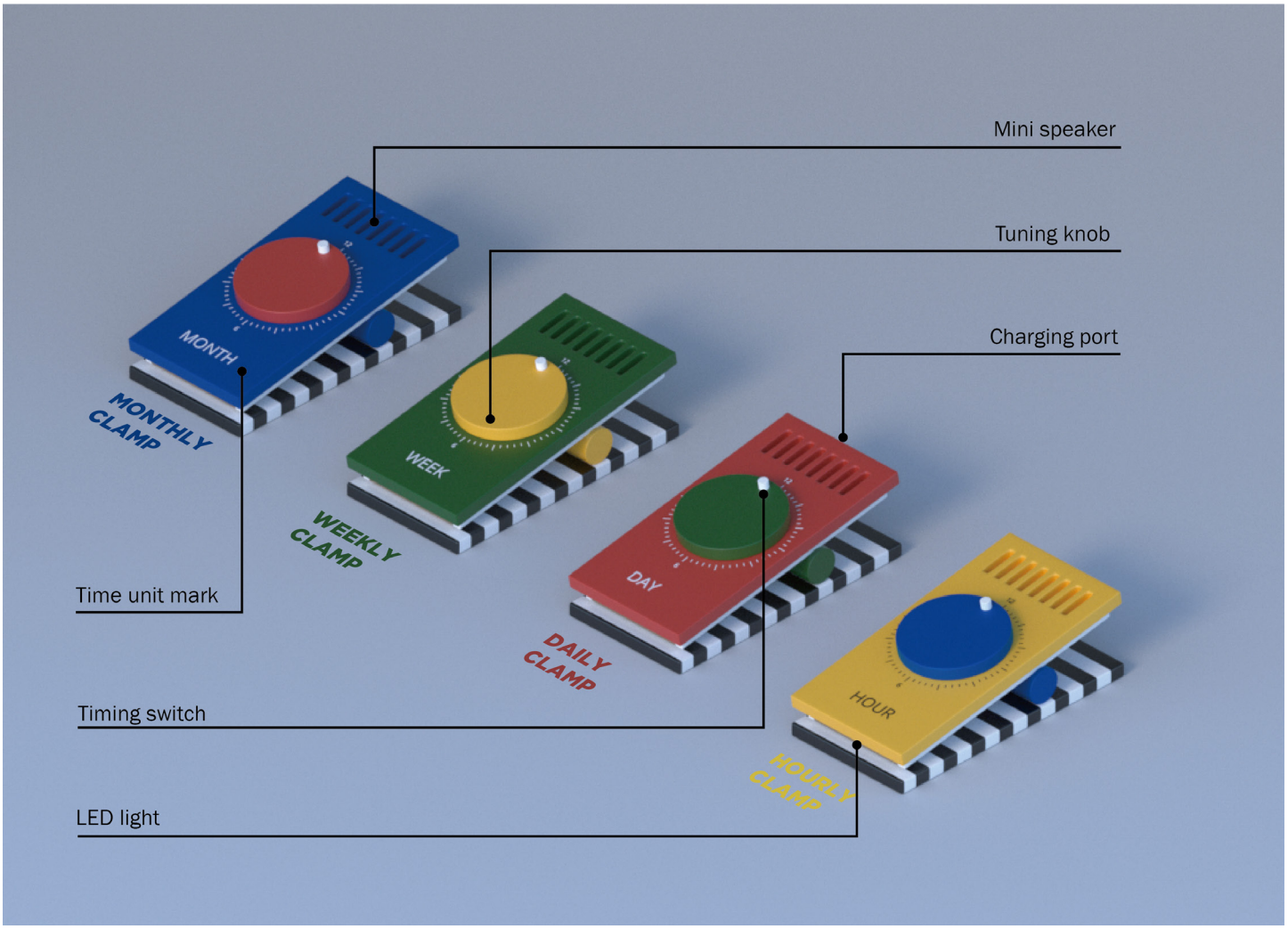


Figure 54 Final design

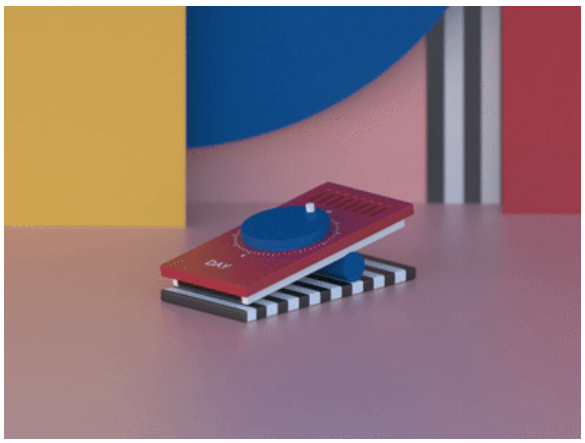


Figure 55 Demo video (https://youtu.be/0nupC1bYzCA)

Figure 56 Control interfaces on the phone

Figure 57 AR find function

Evaluation

EVALUATION

After ideating the concept artifact, it is evaluated and analyzed. The results point out recommendations for further development of the theoretical framework and directions for future research.

Background

The final design described in the previous chapter is deemed as a concept artifact that embodies the theoretical framework. It is aimed at eliciting intrinsic responses and provoking thoughts. The evaluation is aimed to check whether or not the design could lead to various ways of use and whether or not the resulting expansion of capabilities is of intrinsic value.

Method

Participant Recruitment

Four participants who attended the second round of sessions were invited to this last round of sessions. For a design that has been intentionally made open to various interpretations and purposes of use, it is important to gather and incorporate a variety of assessments from a diverse population of interpreters, allowing outsiders to get a rich and layered view of how the system is used, the roles it plays, and the cultural implications it suggests (Sengers & Gaver, 2006). Hence, four young designers were invited as external evaluators to provide a more objective viewpoint. The demographics of the newly recruited participants were listed in the chart below. All names have been changed for privacy considerations.

Participant Name	Gender	Profession	Time (min)
Faye	Female	IPD graduate	24
Libert	Male	SPD graduate	18
Teresa	Female	PhD Design	54
Hannah	Female	SPD student	23

Table 6 Information about the sessions

Ethical Consideration

Permission for recording was obtained before the start of the session. Photos taken during the sessions were approved by the participants. Moreover, the project proposal and data management plan were reviewed and approved by the Human Research Ethics Committee (HREC) of TU Delft.

Procedure

Activity 1

First, three still images were shown to the participant, and he/she was asked to express his/her feelings or preferences towards each style. Then the participants were asked to make associations or wild guesses about the object they see based on their own assumptions.

Activity 2

A demo video demonstrating how the object works were played for the participant. Then the participant was asked to explain how the object works according to their understanding. The misunderstanding was corrected if there was any. Then the participants were prompted to talk about how it might be used to support them by describing different situations coming into their

minds.

Activity 3

Interfaces of the application connected with the object were presented and introduced to the participant. Questions about the functions were clarified if there were any. Then the participants were prompted to think of new situations of use.

Closing

After showing all features, the participants were encouraged to share concerns or extra thoughts and feelings about the design.

To achieve the third aim of evaluation mentioned before, two slightly different evaluation processes were set up for older participants and designers. What's worth noting is that the older participants who have been involved in this project from the beginning were informed about the project background while the four designers knew nothing about this project in the beginning. It is only after demonstrating all features of the design, the context of the project was introduced to the designer. This is the main difference between the two set-ups (table 7&8). Dynamic feedback (Sengers et al., 2005), a strategy in which collected information was used to provide a stimulus for reflection, was used here as an approach to figuring out what values are unconsciously built into the design and what are their effects. Many interesting insights came out of this stage.

Data Collection and Analysis

Two out of eight sessions were conducted online and all sessions were recorded. The investigator reviewed the audio recording and extract important quotes about use scenarios/events and their thoughts or attitude (Appendix J). The sources of quotes are labeled in different colors. The older participants' are in red and the designers' are in black. The mentioned use scenarios were classified by the theme of capabilities in Nussbaum's list (Figure 58). The chain of thoughts were presented by a bull's eye diagram with three layers including the association, related events, and values (Figure 59).

	Older Participants
Activity 1	Choose preferred styles Make guesses about the object
Activity 2	Watch demo video and think of situations of use
Activity 3	See demo pictures and think of new situations of use
Activity 4	Share other thoughts or comments

Table 7 Evaluation process for older participants

	Designers
Activity 1	Choose preferred styles Make guesses about the object
Activity 2	Watch demo video and think of situations of use
Activity 3	See demo pictures and think of new situations of use
Activity 4	Reveal the context of the project Share other thoughts or comments

Table 8 Evaluation process for young designers.

Findings

Whether or not the design could lead to various ways of use and whether the resulting expansion of capabilities is of intrinsic value

The mentioned scenarios turn out to fall into various categories of capabilities including practical reason, bodily health, life, senses imagination and thoughts, emotion, play, and other species (Figure 58). This validates that the artifact indeed can accommodate various ways of use in different situations and have the potential to strengthen different capabilities.

I also made a comparison between the use scenarios from older participants and designers to see how different they are. Generally speaking, in most categories the use scenarios are evenly from older participants and designer. But only designers mentioned events related to ‘senses, imagination, thoughts’ and ‘play’. We can also see that the specific use scenario mentioned by individuals is highly related to their personal lived experience.

whether the associated meaning provided by the everyday object (in this case, clamp) is enough to hint at possible ways of use;

I clustered and structured participants’ quotes in the three-layer bull’s eye diagram. The common associations elicited by the clamps are put in the middle. The use scenarios related to the original associations are in the second layer near the association. The values behind the use scenarios are extrapolated and put in the outer layer. This diagram clearly showed how the original associations elicited by the object in the inner circle can trigger the natural envisaging of different ways of use and how different values can be realized. This indicated that the associated meaning elicited by the everyday object (in this case, clamp) is enough to hint at possible ways of use.

Please refer to Appendix K for high-resolution images.

Figure 58 Clusters of use scenarios

Figure 59 Bull's eye diagram

Design Implications

Getting the ingredients complete is far from cooking a good meal and so is crafting magic intra-action. We still need to get the correct recipe to make magic happen. In the prologue of chapter 5, we already identified the key elements we can use as design handles. The tensions among the elements are addressed in this part. This section will list the design protocols embodied in the concept artifact to lower the misalignment between the perspective of use and the perspective of design while remaining the design open to a variety of use.

Protocol 1: Directional Physical Affordances

Making deliberate decisions on creating users' mental representation which is composed of high-level object properties (Lebrecht et al., 2012) and how to effectively design the intended mental representation. Familiarity is the key to guiding the intra-action process and lowering the misalignment (Figure 60).

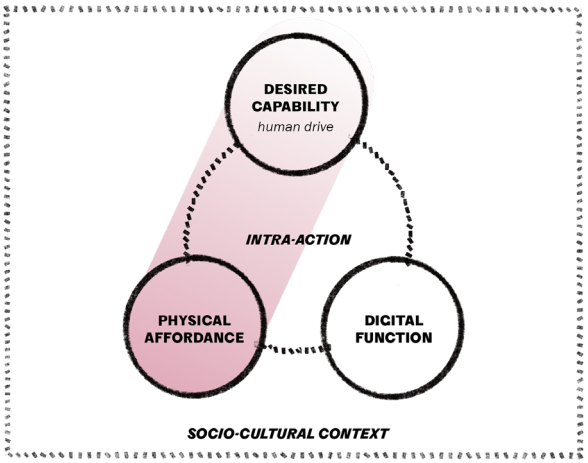


Figure 60 Directional physical affordances

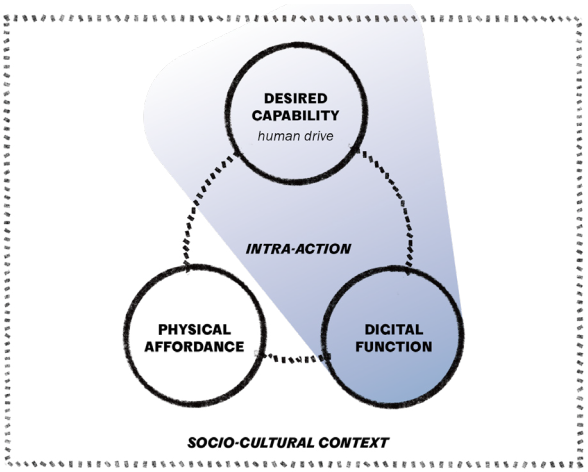


Figure 61 Adaptable digital functions

This protocol can be translated into the design question as follows:

How can people sense and respond to it? How can it be heuristic in what way?

Protocol 2: Adaptable Digital Functions

To remain the variety in use so as to adapt to different human drives, the purposes of use enabled by digital functions should be open. This requires mindful decisions on adding digital functions. The adaptability of functions is the key to maintaining openness in design (Figure 61).

How to achieve the appropriate level of adaptability is also crucial. The functions should be located at the middle level (Figure 63) according to Don Norman's (1986) ladder of functions. High-level functions are too specialized and already closely matched to the task.

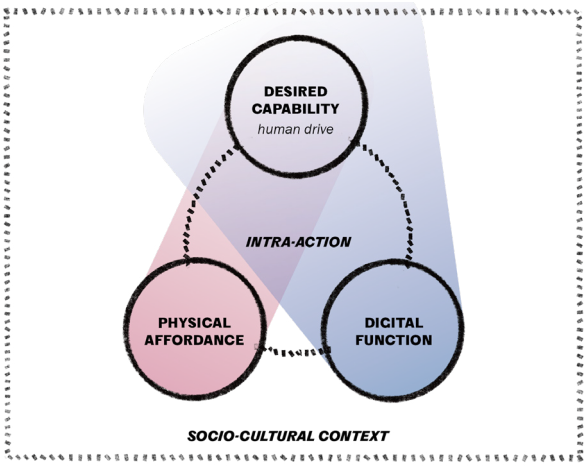


Figure 62 Meaningful combination

For instance, the spelling checker is powerful and well-matched to its purpose but of little aid outside its domain. Low-level functions are highly configurable and customizable but too primitive to be easily adopted. For example, If This Then That (IFTTT) proves to be a versatile tool to realize many goals but it requires prerequisite knowledge to work with that not everybody has. The middle-level functions are adaptable enough to accommodate different needs but also easy to adopt. This is important to maintain openness while avoiding ineffective appropriation in design. It's always easier to say than do though.

This protocol can be translated into a design question as follows:

By adding this function, what is closed and what keeps open? Can people easily use the function for various purposes?

> *Being adaptable is also not equal to being multi-functional. As put forward by William Buxton (2001), the multifunction appliances which he called 'super appliances' (Figure 64) indeed has the potential to satiate more than one use purposes but at the cost of complexity. This is exactly what I wish to avoid — increase the complexity in use that might cause ineffective appropriation.*

Figure 64 The Swiss Army Knife is a typical example of the super appliance.

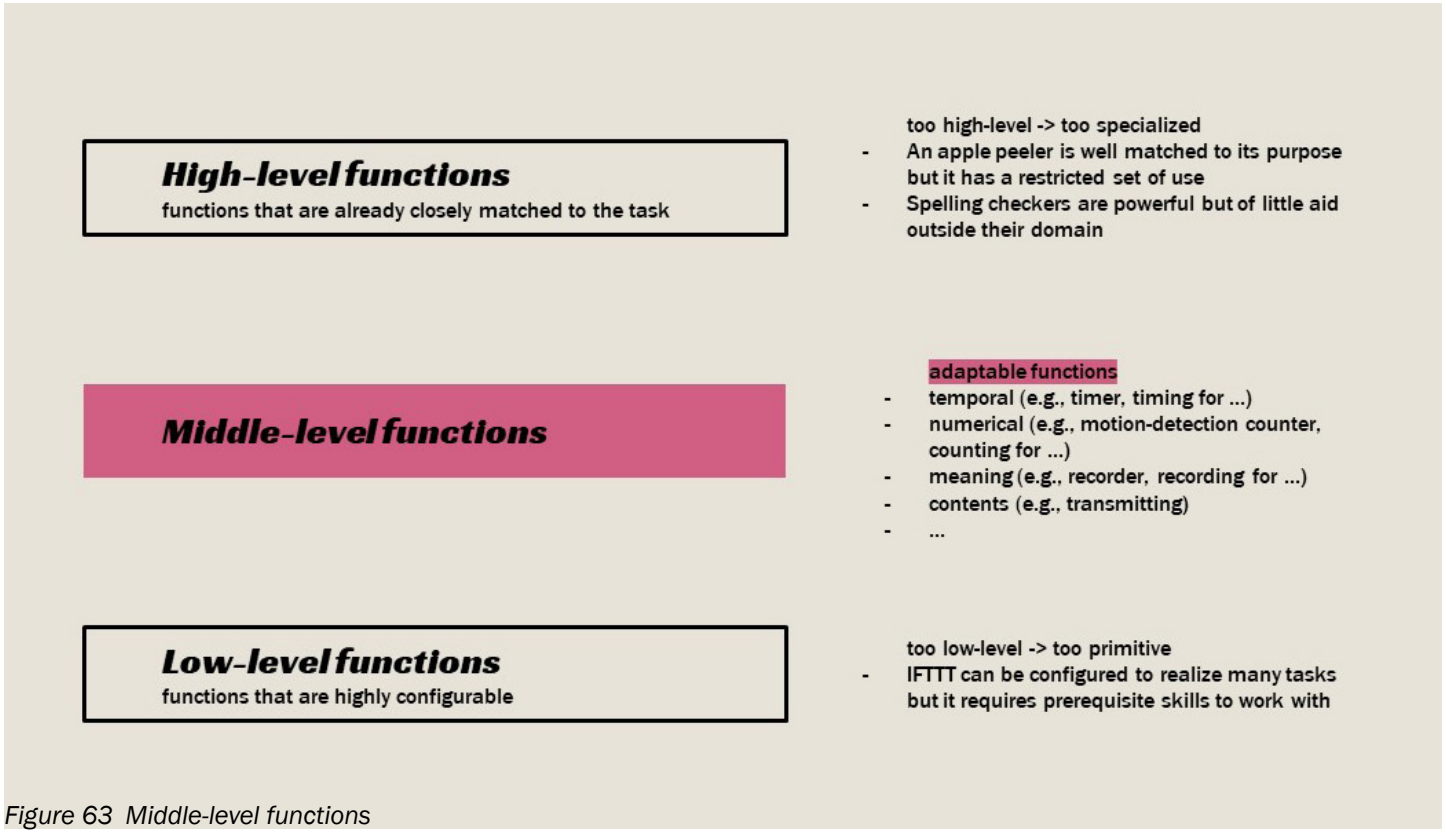


Figure 63 Middle-level functions

Protocol 3: Meaningful Combination and Conversion Factors

Try to put the affordance-function pair in daily contexts to see whether it is a reasonable combination. It requires continuous inspection of the aspects that are open. While providing the heuristic/directional cues, designers should keep on checking what possibilities have been excluded and what remains open. Do NOT keep both physical affordance and digital functions open. This protocol is crucial to striking the right degree of openness and avoid ineffective appropriation.

This protocol can be translated into a design question as follows:

Does the pairing of physical affordances and digital functions make sense? Is there any obstacles that might hinder the adoption process?

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Takeaways

- Design implications brought by previous research can be summarized as three design protocols that can be valuable for design practitioners: (1) provide directional physical affordances to hint at the possible use scenarios; (2) provide adaptable digital functions to remain the openness in use; (3) check the pair between the affordance and function to avoid uselessness of design. The next chapter will briefly discuss the renewed elements of the intra-action model and propose an alternative design process derived from the exploration in this chapter.

Ramifications

RAMIFICATION

Based on the design implications drawn from previous research, I took a reflection on the intra-action model and renewed each element with updated meaning.

Renewed Theoretical Framework

Beyond Physical Affordances

From the observation in the sessions, we could see responses elicited by the provided objects include not only bodily reactions but also figurative associations. These associations including how people sense and respond to a certain object can be influenced by various factors, which consist of not only physical affordances but also other factors like aesthetic styles, past experience, etc.

For example, many participants associated the pin with documents and paperwork, which denotes the related social practices imprinted on common everyday objects can be quite strong and common among different people. This indicates the universality of high-level properties and how people react to certain factors can be quite similar. This leads to an expansion of the original component (physical affordances) to high-level properties. In this sense, it is suggested that designers should pay more attention to the associations people usually draw or other responses people usually have thereby moving one step closer to the use perspective (Figure 65).

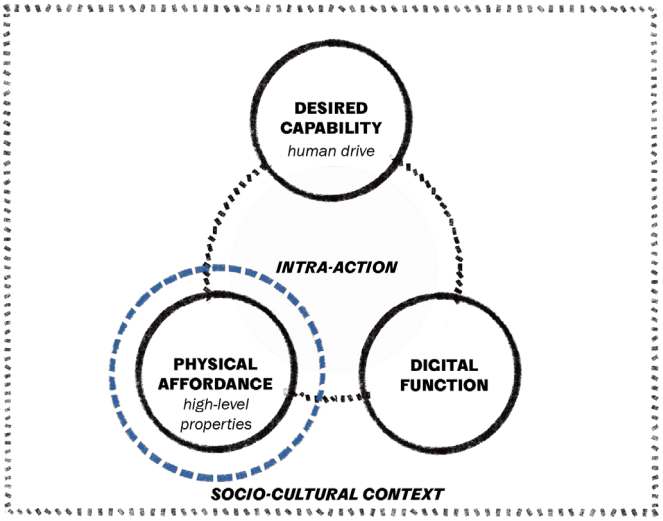


Figure 65 Beyond physical affordances

When the Unfamiliar Becomes Familiar

With the expansion of physical affordances, I found that the relation between the two originally separate components (physical affordances and digital functions) is no longer separate but

intertwined. Because during the long course of use, the digital functions can be internalized as part of the high-level properties. For example, when people are familiar with the timing property of the oven, they can also jump out of the most closely associated use scenarios like cooking but use it to time for anything they want. This is also crucial to inventing extraordinary ways of use. Therefore, the task for designers boils down to distributing the percentage of familiarity and unfamiliarity.

This suggests a changing model in different stages of use. In the adoption phase, the familiarity is mostly provided by the physical properties and the unfamiliarity is from the abstract digital functions. Over the course of use, the digital functions will become more and more familiar to users and be internalized as part of the high-level properties and the two original components will draw closer and begin to merge (Figure 66). This is a dynamic process of the post-adoption phase.

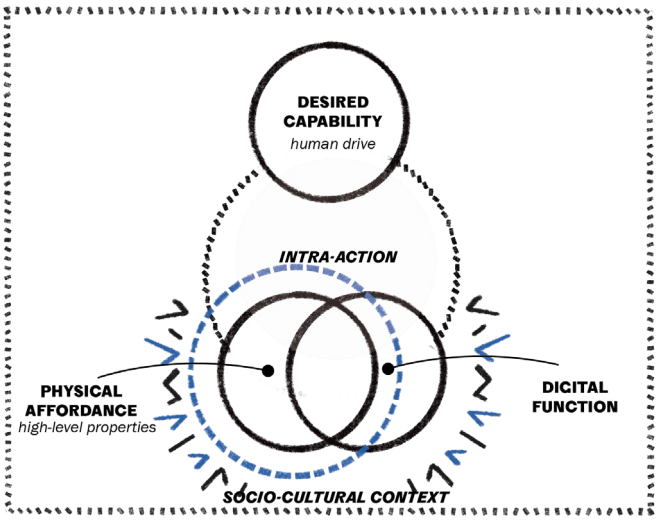


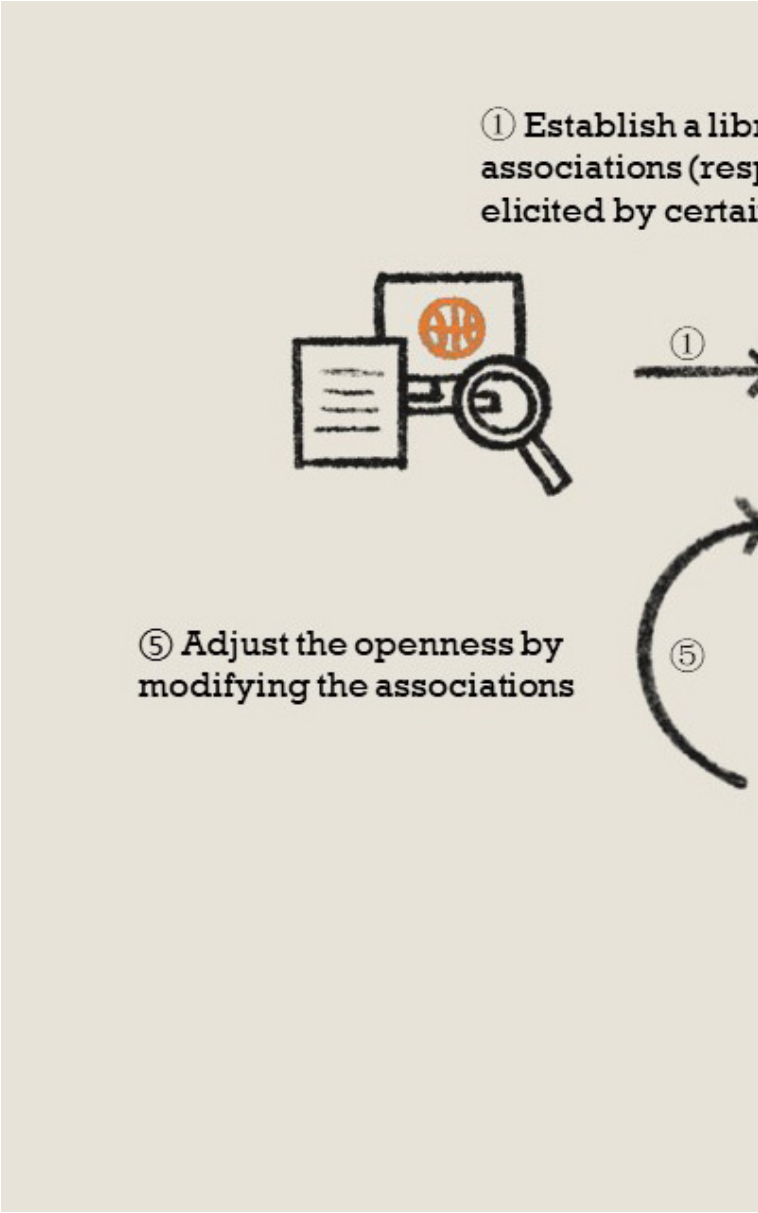
Figure 66 When the Unfamiliar Becomes Familiar

Conversion Factors

The third component in the model —- desired capabilities —- can be seen as the final outcome of the tension between the familiar part and the unfamiliar part. The intersectional area the familiar and the unfamiliar directs can be represented by what capabilities can be achieved. Besides, in order to truly transform the assets provided by the technological objects into capabilities, the conversion factors should be taken into account. This prompts the design that reflects respect for human skills at various levels including motor-sensory skills, cognitive skills, social skills, and so on.

Alternative Design Process

The following design process is an attempt to provide a systematic design guideline to strategically steer the process of design for openness. The biggest difference between this design process and the traditional one is the focal point. Usually, the design process starts from one or several pre-defined tasks or goals to be achieved by the users and the whole process is centered around helping users to complete their tasks or achieve their goals. However, in the alternative design process, the starting point is the meaningful associations established between humans and the properties of objects.



It can be divided into 5 steps (Figure 67):

Step 1: Establish a library of associations (common responses elicited by certain properties)

So many associations can be established from observation of how humans respond to certain properties of objects. Different sources not constraining within fields like perceptual psychology, cognitive science, biology, and so on can be used to form the items in the library of associations. The establishment of the library can increase our awareness and understanding of human senses, cognitive ability, and so on. This is a crucial step to develop technology artifacts to leverage those associations triggered by human disposition.

For example, humans prove to have accurate memory in response to different sounds. Google Latitude Doorbell utilized this mechanistic skill of sound recognition and associated different chimes with different persons at different distances. It was such a clever way to convey quick information through sounds by tapping into unique human capacities. And the humans' instinct to differentiate different sounds is what can be collected in the association library.

Step 2: Select certain common associations which are applicable in the target context

There might be many associations. How to decide what to use? One way to narrow down the target associations is to get inspired by target users' lived experiences. What daily objects do they already use frequently in their daily life? What unique associations do they have?

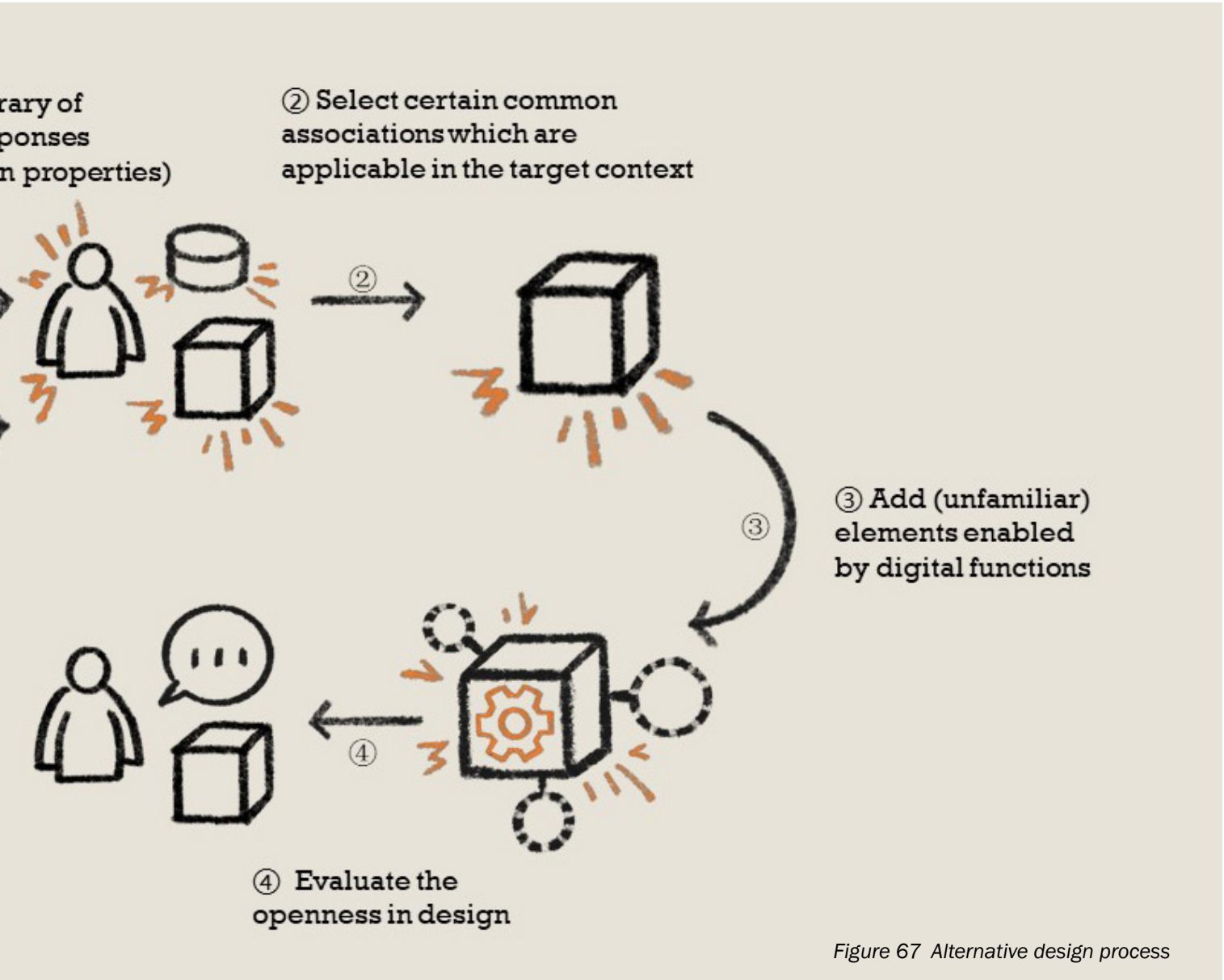


Figure 67 Alternative design process

Step 3: Add (unfamiliar) elements enabled by digital functions

After selecting the associations to build on, new functions can be added to make the ways of use possible. For example, people are familiar with chimes in telling time. The distance information conveyed by different chimes with different pitches in Google Latitude Doorbell is an unfamiliar function based on a certain degree of familiarity.

Step 4: Evaluate the openness

You will never know how the users will respond to the artifacts until they are put into use in the real life. It is important to validate the effectiveness of association through testing in vivo.

* Capability approach can also be used in the evaluation phase to test whether the conversion factors are met in the context.

Step 5: Adjust the openness by modifying the associations

The test results help provide insights into the degree of openness in design. If it proves to be too open to be effectively appropriate, iterations can be made by strengthening the associations which are built on or changing the associations to others.

Critical Reflection and Future Directions

Even though the design strategy together with the alternative design process seems promising, it still requires future research to validate its effectiveness and demarcate its limitations. Drawing on the evaluation sessions with professional designers, I identified the potential risks and proposed the recommended use scope of this design strategy.

Since the design process aims at creating a purposefully purposeless design, the risk of losing meaningful purposes of use should be kept in mind. How to decide what digital functions should be added? How to make sure the combination makes sense to users? Besides, we should also be wary of 'overdesign' by using this strategy. Is it necessary to add digital functions? How much added value is created?

Additionally, identifying the boundary of the use scope ensures the appropriate use of any design strategy. Apparently, openness in design is not suitable in the context where the problem to be solved or the task to be achieved is clearly defined. Instead of put the efficiency of getting things done in the first place, design for openness prompts a playful way to engage humans. It works well in the following design conetxts: (1) to overturn implicit stereotypes; (2) to break design fixation; (3) to conceptualize ludic design (Gaver et al., 2003) without clear purposes.

Based on the research described in this report, future directions are recommended as follows. First, more evaluations conducted in the real life should be conducted. For now, the evaluation of the concept artifact was conducted in vitro instead of in vivo due to the limited time and the lack of technology support. In the ideal situation, the evaluation should be done with workable prototypes and users should experience the whole process from adoption to post-adoption. The long-term observation of the spontaneous developing process during which users generate different ways of use in their daily lives will definitely bring more insights into the use of the design strategy in the real life. Second, a double-blind experiment can be done with professional designers to evaluate the effectiveness of the design strategy. For now, how effective the design strategy can break design stereotypes or design fixation remains unclear. Third, the proposed alternative design process presents a way to move beyond the traditional design process. Current design practice mainly focuses on things like usability and user satisfaction. Shifting the focus of design from problem-solving to human responses opens up an exciting opportunity space for the future development of the design field.

Takeaways

- This chapter presents some design ramifications derived from the previous exploration. First, I further developed the intra-action model by iterating the meaning of each component and detailing the tensions that balance each component. The framework is the foundation of developing an alternative design process driven by associations. The ambition to develop the alternative design process should be supported by future solid research in this direction. The limitation of the alternative process is also discussed.

Intermezzo: A few more words about high-level properties

Admittedly, some of the factors have less predictable priming effects than others. For example, it is much easier to predict what action people can perform with an elastic band regarding affordances than to predict what emotion the color blue might arouse regarding emotion-elicitation. Hence, physical affordances still constitute the core and solid part of this high-level property set which designers can manipulate strategically to steer the intra-action process.

The set for inspiration is enumerated below:

- *Affordance*
- *Name*
- *Aesthetic style*
- *Emotion-elicitation*
- *Practice-Association*
- **Personal experience*
- **Morphing of the form*

This list should be seen as a growing list. The development of the feedforward set can draw inspiration from different fields such as the features of human sensory and mobile systems, psychological effects, etc.

Notwithstanding the nudging effect is more tenuous for the peripheral softer part in the feedforward set, it is still of crucial importance to take them into consideration. One factor worthy of noticing is personal experience. Obviously, this is quite personal and goes against generalization. However, it is listed here because the personal touch added to the artifact is most likely to create emotional resonance thereby engaging the user. Imagine a quasi-record player product that can randomly play music according to the listening history, it can certainly arouse more fascination in vinyl lovers than a digital music player. Even if we utilize less personal experience, it can still work well in nudging if it succeeds. In the case of this project, for instance, the researcher tapped into the rich social practices associated with everyday mundane objects together with a directional physical affordance to create a joint force to steer the entry use stage.

Design Implication

Manipulate as many components as possible to create a joint force and ensure the intended heuristics outstanding and comprehensible.

Taking the larger socio-cultural context including social norms, cultural background, and human abilities (conversion factors) into account. (The daily use meaning of a cheese scraper might not be obvious to people living in a country where people rarely eat cheese.)

Closing Remarks

CLOSING REMARKS

It is the first time for me to finish such a large individual project which cross several months. This chapter captures some of the most valuable learnings or personal reflections I wish to take with me to the future.

Interwoven Research and Design

One notable characteristic of this project is that the process of developing the theoretical arguments and crafting the concept artifact is simultaneous. Due to the linear feature of textual narrative, I first showed the final design concept followed by the design protocols and the design framework.

The project was the first trial for the author to approach framework theorizing and artifact crafting in parallel. The initial two design concepts helped surface the initial theoretical idea (Chapter 5). The following co-speculation session was used as an essential source of input to further develop the theoretical idea (Chapter 6). In combination with other theories, the concept became more clear and is further refined in the form of the concept artifact (see chapter 7 & 8). This approach is jointly informed by theoretical and designerly knowledge and competencies.

It was later in the project that the investigator came across the term concept-driven design and surprisingly found it overlapped with the methodological approach used in this project. It is part of a broader set of analytical strategies for design including longstanding efforts to develop models and guidelines (Caroll, 2003) like this project. This project has just been through the first endeavor in the embodiment of theoretical arguments but it already exemplified the huge potential to take a designerly approach to do research.

Reflexivity in the Project

Looking back, I was amazed by the path I took in this project and how everything I did in the past few months came together and consisted of the narrative I presented in this report. If I need to say just one thing that I learned in such a complex and open-ended project, I would say how to formulate research questions to guide the research activities. To be honest, some of the research questions were articulated verbally in hindsight, but each turn of the research direction has been guided by an unanswered question stringing together the whole journey of exploration.

During this thesis, I started by asking why the current common understanding of aging is so negative. This results in a critical inquiry into the origin of the current negative narrative around aging and how such framing influences today's technological innovation for older people. The intermediate findings revealed the gap between the needs in the aging process and the technology design thereby generating the first design goal to cope with this gap. Literature study inspired the direction of 'design for openness'. Findings from following co-speculation sessions surfaced the potential risk of openness in design thereby pivoting the research direction into coping with the risk.

This constructive explorative journey required paying attention to the ambition and its goals and swiftly framing and reframing the research question based on intermediate findings. The constant reflections and considerations on the process and outcomes of research activities

reflect the reflexivity in this project. In reflexive practice, there are two types of reflection identified by Schön (1983), namely reflection-in-action (reflecting during creative activities) and reflection-on-action (the conscious reflection performed after the action has been taken). In retrospect, both kinds of reflections were experienced in this project, resulting in formulating the research questions on the fly and structuring the research journey in such an explorative way. It is not easy to maintain a clear direction in research in the chaotic explorative process. I learned to frequently return to the research questions or just by asking myself what research question I want to answer to navigate through the complexity of this project and continuously push the research forward.

Theories Study

Theories are of great importance in this project, which serve as a solid base for related research activities (e.g. constructing the setup for semi-structured interviews), They provide a firm handle while grappling with the complexity of this project, and also serve as a source of inspiration for the design. This project has been inspired by a plethora of theories. The Successful Aging Model and the personhood turn in the care model directed the author to take a holistic and personal approach to understand aging people's needs. This led to the utilization of the Capability Approach to achieve a comprehensive understanding. Entanglement Theories, a label coined by Wanda Orlikowski (2010), all start from decentering humans and putting them on the same level as non-humans. Such a perspective 'posits the social and technical as ontologically inseparable from the start' (Introna, 2014). Among the wealth of entanglement theories, post-phenomenology (Ihde, 1990) and agential realism (Barad, 2007) underpinned the author's stance toward the relationship between humans and non-humans. The concept of intra-action was utilized to develop a theoretical model.

However, it is not an easy journey. The theory study, on the one hand, blows my mind with new perspectives I have never thought of thereby making me humble and considerate when making design decisions. On the other hand, it also once stuck me in abstract thoughts and hindered me from moving toward concrete solutions. It is a double-edged sword. How to translate abstract theories into actionable insights is a skill I learned along the way. Climbing up and down freely on the ladder of abstraction is what I hope to continue training.

Conclusion

The main contribution of this project is to propose a compromised 'design for openness' strategy to close the gap between needs emerging in the aging process and what gerontechnology provides. I used the Capability Approach as the theoretical base and developed a pedagogical path to translate abstract philosophical concepts into practical tools to approach aging people and obtain insights into their well-being and daily needs.

Empirically, this project contributes to challenging the current common understanding of the aging process and generalized three main pitfalls the current gerontechnology might easily fall into, which surfaced the gap between technology and aging needs. This laid the foundation for follow-up studies. The risk of 'openness in design' was identified through co-speculation session switch older participants. Methodologically, this project develops a handy toolkit based on the Capability

Approach to probe into older people's life in a holistic way. It shows a methodological path to put philosophical concepts into practice.

Apart from the empirical and methodological contributions, the development of a theoretical framework —- the magic intra-action model —- and the design for heuristic openness guidelines provide valuable insights for design practitioners. The conceptualization of the concept artifact embodies the theoretical arguments, being on par with the theoretical advancements.

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