

Increasing Economic Awareness Using Emergent Displays in a Domestic Context

A Master's Thesis



Danske Bank

Christian H. Lorentzen
Lasse Legaard

Acknowledgement

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Abstract

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Introduction

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Introduction

0.1 Motivation

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0.2 Research Question

0.3 Research Approach

0.4 Outline of Thesis

Framing the Domain

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Framing the Domain

This chapter provides insights into the domains of personal financial management and technology for the home which constitute the main areas of interest in our thesis. The purpose is to create a general foundation...

1.1 Designing Technology for the Home

The home is a dwelling place where inhabitants find refuge and safety; it is a place of security and protection where everyday cares fade and the things and people that one loves become the focus. It establishes a sense of belonging somewhere in the world and can have various physiological influences on the inhabitants, ranging from behavioral and emotional to even affect the overall mental health [9]. Designing technology for this context requires an understanding of the home as a “lived in” environment where technology is used and integrated in numerous ways and where many different activities are undertaken. The home is a messy place where rooms often have multiple purposes and are configured by the inhabitants to fit their routines and specific needs. The challenges of designing for this context stand in stark contrast to the ones faced in the work sphere where information technology has been widely used for decades. Technology for the work sphere focuses on dedicated support of particular work activities that are isolated from the environment in which the systems are placed. As a consequence, the design techniques have focused on supporting the construction of dedicated systems for particular kinds of work rather than a broader consideration of the system and the space which it is used in [24]. For this reason, we must be careful not to use the familiar concepts derived from the workplace when designing for the home as there is a risk of migrating a set of values that may be

Chapter 1. Framing the Domain

inappropriate for the domestic context [13]. As Gaver phrases it [21]:

”

There is a danger that as technology moves from the office into our homes, it will bring along with it workplace values such as efficiency and productivity at the expense of other possibilities.

— Gaver, 2001

Intuitively we know that the workplace and home are indeed very different domains, but the challenge is not simply one of understanding this, rather it is one of developing insights into how the home is different in order to create technologies that are fitting and appropriate to the setting. Hughes et al. have investigated the role of technology in the domestic environment with a focus on the home as a “lived space” and how technology can be “made at home” in such a setting [24]. They found an important theme to be the aesthetic character of the home, as it is an essential part of the transformation of a house into a home. Inhabitants work at their houses by decoration and configuration in order to make them into homes and these aesthetically focused “home making” activities are of great importance to them as they encompass choices that reflect both personality and lifestyle. This emphasizes that the aesthetics are not to be taken lightly when designing technology for the home; it might even be a prerequisite that it is deemed aesthetically pleasing to be considered let into the home. However, there is a natural compromise between the aesthetic and functional traits of domestic technology. The more crucial the functionality is considered to be, the more willing we are to compromise on the aesthetics. In this regard, it is important to be aware of the close relationship that exists between the aesthetic and practical organisation of the home as these are closely intertwined [24].

1.1.1 Domestic Routines

Researchers working in the field of domestic technology have identified the everyday domestic routines as a significant and highly interesting characteristic of the context [14, 12, 44]. Tolmie et al. describe how routines essentially bind everyday life together by enabling inhabitants to take action without constantly having to reason about their activities [44] – routines are what makes everyday life flow:

1.1. Designing Technology for the Home

”

Routines are the very glue of everyday life, encompassing innumerable things we take for granted such that each ordinary enterprise can be undertaken unhesitatingly... Routines help provide the grounds whereby the business of home life gets done. Routines mean that people can get out the door, feed themselves, put the children to bed, and so on, without having to eternally take pause and invent sequences of action anew or open up their every facet for inspection or challenge or to constantly have to account for what they are doing with explanations or rationales.

— Tolmie et al., 2002

Crabtree et al. have studied the routines of the home by explicating the practical action that inhabitants routinely engage in, i.e. the reoccurring sequences of practical actions [12]. They found the routines related to production and consumption of communication in the home particularly interesting and have, based on these routines, constructed a set of key organizational features that may instruct the development and placement of technology in the home. The features include *Ecological Habitats*, *Activity Centres* and *Coordinate Displays* and represent the patterns of technologically mediated activity in the home [39]. Ecological habitats are places where technological artefacts and media live and where inhabitants go to find specific resources. The artefacts are placed in these ecological habitats as a matter of routine use and are thus easily located; habitats include places such as desks, shelves and tables. Activity centres are places where artefacts are recurrently manipulated and information transformed. Ecological habitats and activity centres may be different places but can also coincide; a noticeboard may at one time be a habitat for information about important upcoming events and at another a centre where the information supports social interaction. Likewise, the desk might at one time be a habitat where books, documents and reminders live and at another a centre where reports are written and emails sent. Coordinate displays are places where artefacts and media are displayed in order for inhabitants to coordinate their activities. They are constructed at easily visible sites with the purpose to trigger practical actions such as remembering to pay a bill or buy tickets for the match. An important point here is the fact that it might not be the same person who places the reminder to pay the bill and actually takes action; the displays act as ways for the inhabitants to coordinate action. Coordinate displays may also coincide with ecological habitats or activity centres. Taking the example of the noticeboard, it may act as a display for information that enables the inhabitants

to coordinate social activities. As the examples indicate, it is important to remember that even though the three organizational features are distinct, the places in which they are situated often overlap, meaning the places will take on different functions at different times. The organizational features serve as conceptual and analytic resources to help guide the placement of domestic technology so it may meet the daily needs of the inhabitants. Identification of the ecological habitats, activity centres and coordinate displays in a particular setting, thus provides insights into prime sites for domestic technology deployment [13].

1.1.2 Ubiquitous Computing in the Home

The domestic environment has received a great deal of attention from the ubiquitous computing community, especially through purpose built “lab houses” that aim to explore both the potentials and shortcomings of current technology and infrastructure as well as visions of the future home e.g. [27]. While exploring the potential of full blown ‘smart homes’ is an important endeavour, so is considering the constraints of the real world on the technologies we design. As Edwards and Grinter put it [14]:

“ ”

new homes may eventually be purpose-built for such smart applications, existing homes were not designed as such. Perhaps homeowners may decide to “upgrade” their homes to support these new technologies. But it seems more likely that new technologies will be brought piecemeal into the home; unlike the “lab houses” that serve as experiments in domestic technology today, these homes will not be custom designed from the start to accommodate and integrate these technologies.

— Edwards and Grinter, 2001

This predicted piecemeal integration of technology into the home calls for research that complements the current holistic approach to domestic technology by considering how inhabitants might bring domestic technology into their “dumb” homes. In this regard, research has broadly focused on three different approaches to the development of interactive domestic technology [38]: *Information Appliances* which are self-contained interactive devices with specific functionality. These are often constructed by layering interactive functionality onto existing household appliances, for example using touch screens.

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Interactive Household Objects combine existing household objects with interactive capabilities to create new forms of interaction which often build upon the values associated with the existing household object. And lastly *Augmented Furniture* where interactive capabilities are added to the furniture in such a way that interaction is mediated through embedded sensors detecting actions with the furniture.

1.2 Personal Financial Management

A significant amount of our daily decisions and routines are rooted in money. Everything from buying basic commodities to planning for buying a new house is weaved into our financial values and habits. Many commercial tools – mostly apps [33, 42, 34, 2, 31] – have been developed to support and engage people in personal finances, however the majority of these tools focus on extensive data visualization and/or economic planning which is proclaimed to fail in real-life situations [41]. Also, since these tools are mainly deployed on multi-purpose platforms, such as smartphones or laptops, many applications are fighting for our attention once we engage with these devices and consequently users might find themselves roaming social networks, making phone calls or playing games instead of staying in touch with their finances [11, p. 3894]. Even though money is a substantial part of our life, financial management and interactions (e.g. saving, trading or buying) have not received much attention from the HCI community. Kerber et al. created a household account book which is able to capture data from receipts using optical character recognition [26]. This feature was used to ease the process of entering data, but aside from that their solution is not that different from today’s smartphone applications. A different and very interesting take on personal finances is the future-focused smartphone application Weekly [5]. Based on a spending goal and daily transactions the application is able to provide users with a financial forecast, e.g. spending less money than planned results in a sunny forecast whereas spending more leads to a rainy forecast. A more physical approach to tracking finances is SmartPiggy; a smartphone-connected piggy bank which uses gamification to help users keep track of multiple saving targets [43]. Many similar products have been developed for commercial use [16, 4, 46] (see figure 1.1).

In 2014 Kaye et al. [25] conducted a foundational study where they investigated how people keep track of their personal finances. The study excluded financial professionals and people who systematically study finances

Chapter 1. Framing the Domain



Figure 1.1: Picture 1: ERNIT; Picture 2: Clever Kash; Picture 3: Porkfolio

and aimed to achieve general diversity in terms of age, income, assets, job and the presence of children and partners. In the paper the authors present three main findings: emotional reasoning for financial decisions, tools for tracking money and accounting for the unknown; the latter refers to the inability to predict future events that have an impact on personal finances and is not of interest to our project. According to Kaye et al. [ibid] most of our economic decisions are based on emotional grounds, which might not come as surprise (to some) since the notion of homo economicus, i.e. the idea that humans are self-interested actors who make economic decisions based on rational judgement, has been declared obsolete within economic theories [?]. The researchers found that people usually acted upon existing knowledge, prior experiences, worries, personal values and future dreams meaning that spendings are not always based on profit maximization or rational reasoning. Their second finding is related to tools for tracking personal finances. In general tools were divided into two groups, namely paper systems and digital systems. The paper-based systems varied from simple index cards to more elaborate lists and calendars, and were often optimized for people's financial focus (income, savings, stocks, etc.). Surprisingly the digital systems were not very popular. People expressed concerns regarding security and found the commercial aggregations systems (digital systems developed to provide a financial overview) somewhat frustrating mainly due to a poor user experience and lack of freedom. What is interesting here is that most people did not use a dedicated tool, however "*people's sense of their finances came from occasional glimpses at the complex whole, rather than a concerted and coherent overview of their entire situation*" [25, p. 562] meaning that people will occasionally review the last couple of transactions and look for anything that deviates from the expected. In relation to this Kaye et al. coins the term "financial touch" which is comparable to our definition of economic awareness, however their notion also includes temporality, i.e. having ephemeral

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or transitory financial interactions. By the end of the paper the researchers come with some general thoughts and observations. First of all, none of the participants seemed to use systems that integrate all aspects of a financial life, suggesting a need for rethinking existing financial systems or create new interaction experiences. The varieties of physical (paper-based) systems used also shows a great potential for more physical systems. Furthermore, personal financial management tools could also include encouraging prompts and have a more granular approach to privacy, e.g. filtering content based on who is looking.

Despite the small number of HCI studies within the area of personal financial management, Kaye et al.'s article serves as a great starting point for this thesis. They point out that financial decisions are not solely based on rational reasoning and that being aware of one's economic state is tightly coupled to the act of observing transactions patterns and looking for anomalies. As Snow and Vyas [41] they also highlight the misalignment between commercially available products and actual financial practices, and foresee a high potential for more physical products. As their study was carried out in America, it might not be directly applicable to the European citizens and culture, therefore, in the next section, we describe a European study that segments financial customers based on their attitude and stance towards finances.

1.2.1 Segmenting Financial Customers

This section presents information from a report developed by Forrester Research in 2006 [15]. Although the report is more than 10 years old the data presented is still relevant today as it seeks to enlarge the traditional strategies for customer segmentation. In this thesis we will use this information as a way to understand and describe our participants' financial motivation, behaviour and attitude.

According to [15] the web has for many become the main source of information. Complex decisions are often based on knowledge obtained from the web and people regularly use online resources when researching for financial decision. Alongside this tendency many customers steadily adopt new service technologies leading to an increase in number of channels (phone, email, forms, etc.) used to reach the same goal. This increase is not only supported by our client's data but it also shows that the mobile channels are on the rise compared to the more traditional platforms (see figure ??). To accommodate this change of behavior banks need to have an effective way of segmenting customers in order to reach a better understanding of customers' decisions.

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	Description	Needs	Channel preferences
Self-Directed	Make financial decisions on their own; seek best products and prices	Information, value, speed and control	Self-service: - ATMs - Internet
Validators	Some interest in finances; want advice on more complex decisions	Information, value, advice, good service, reassurance and a trusted relationship	Human assistance: - Branches - Telephone - Online chat
Delegators	Bored or confused by finance; want others to make decisions for them	Advice, good service, reassurance and a trusted relationship	In person: - Branches - Face to face at home
Avoiders	Neglect their finances; distrust firms and advisers	Simplicity and speed	Remote channels: - Telephone - Post

Figure 1.2: Types of financial customers. Courtesy to [15]

Historically speaking customer segmentation is not new to most financial service companies, however the current segmenting dimensions – i.e. demographics, contribution, behaviour and attitude – do not fully capture the complexity of customers' behaviour. In general each dimension encompasses advantages and disadvantages, but the most useful and least ephemeral dimension is attitude since people's economic stance change relatively slowly, it is applicable to all customers and it provides a valuable insight into people's behaviour [15, p. 2-8]. Based on financial attitude customers can be divided into four different types. They are as follows: Self-Directed, Validators, Delegators and Avoiders – an overview of each type can be found on figure 1.2. As the name implies Self-Directed customers are highly independent and in most cases make financial decisions without consulting a financial adviser. They often have a strong interest in finances, understand financial products well and make research before making any decisions. Perhaps surprisingly, not all Self-Directed customers are willing to run financial risk for a higher return, and when it comes to more complex decisions such as pension or tax they seek advice from professionals. Compared to the other types they tend to have a better education and work full time. The second type is Validators. They have the same kind of interest in economy as the Self-Directed but lack some confidence when it comes to making decisions. For moderately complex problems the Validators seek out financial advice, but are, in comparison to the Self-Directed type, more willing to take financial risks for a higher return. Out of the four types, Validators seem to have the healthiest economy. The third type, Delegators, find finances boring and/or confusing. They would rather spend time on something else and is prepared to give up

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control to more knowledgeable people. When dealing with finances half of the Delegators wish to talk to other people and from a demographic perspective there is a slightly higher occurrence of women in this category. The last type is more or less oblivious to finances. Avoiders do not have much trust in financial services or advisers, and as a result they tend to neglect their finances completely. Consequently, they usually have an unhealthy economy while their lack of financial knowledge make them more risk-averse because they are not able to grasp the repercussions of their actions [15, p. 10-11]. According to the report the easiest way to spot which segment a given customer belongs to is through their behaviour, e.g. Validators are more likely to buy products through a financial adviser whereas the Self-Directed would probably do it online without consulting a professional. Furthermore, the various types seem to prefer different channels (ATM, internet, branches, etc.) and therefore this can also be used to uncover the type of a customer.

The customer segmentation and the fact that customers' interest in personal financial matters vary a lot, needs to be taken into consideration because it will inevitably influence our findings. Hopefully, being able to make that distinction between different types of users will help us in making more informed decisions hence make better designs.

Establishing a Direction

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Establishing a Direction

This chapter outlines our efforts to establish a direction in the domain of technologically mediated personal financial management in the home. The interviews and workshop presented in this chapter constitute the empirical foundation for our understanding of the domain. The interviews seek to create initial insights into how the users handle financial management with a focus on behaviors in the home. The workshop focuses on how the users handle their finances in the home but additionally provides insights into how the attendants would like future banking experiences to feel like and be integrated in the home.

2.1 Preliminary Interviews

This section presents three preliminary interviews that were conducted in the early stage of this project. Each interview aimed to obtain some general knowledge about (our target group's) financial habits, behaviour and value-set. We conducted an interview with a financial adviser, a woman living with her husband and two kids, and a young couple living together. All interviewees are anonymized in order to maintain integrity and the main findings from these interviews are presented in separate sections. The interview with the financial adviser was held in person and documented using voice recording and notes, while the interviews with our target group members were conducted via Skype using screen recording and phone using voice recording, both complemented with notes. The interview guides used for the interviews can be found in appendix ??.

2.1.1 Financial Adviser

Prior to the interviews with our target group we conducted an unstructured interview [40, chapter 7] with Michael; a 34-year-old senior adviser from Danske Bank with more than ten years of experience within financial counselling. The primary goal of the interview was to gain an overall understanding of how people manage their finances on a daily basis, and how the relationship between a financial adviser and an ordinary customer is currently functioning. The interview lasted around 40 minutes.

After the introduction and the warm-up questions our main session started, and after some time it became relatively clear that many of the answers to our questions resided in the advancement of technology. Before his job at Danske Bank, Michael worked at a smaller bank and he described how he, on a daily basis, had more personal contact with the customers. He mainly ascribed this difference to the amount of financial services offered to customers of Danske Bank, as they now have the opportunity to handle simple financial tasks on their own. Even though it might seem a bit contradictory at first the wide range of services available to bank customers has resulted in a higher focus on customer care as the financial advisors no longer have to perform the same amount of trivial tasks. As Michael describes it: “*a lot of our things [daily tasks] have changed because of IT solutions, I mean, the customers can actually do a lot [economic related tasks] at home*”. During our interview we also asked what he saw as the main reason for unfortunate economic situations and how this could lead to an unhealthy economy. In his perspective undesirable economic situations were often caused by a lack of framing (no budget), and the fact that future projections are difficult to make. Another, yet very important, aspect is how new (young) customers decide on which bank they want to take care of their money. Michael told us about how some people have chosen Danske Bank due to its financial services: “*many customers have opted for Danske Bank because of its [technological services], as others [banks] do not offer as advanced solutions*”. Seeing how banks keep pushing new features to their digital platforms and how customers embrace these features by fast adoption, lead us to believe that self-service and customer empowerment are two key factor in future banking.

2.1.2 Family Mother

We conducted a semi-structured phone interview [40, chapter 7] with Charlotte, a 28-year-old woman living in Western Jutland, Denmark, with her husband and two children. Charlotte works a part time job as a nurse and her husband works full time as a mason. The phone interview was performed on a Thursday morning and took approximately 45 minutes.

When asked to describe her economy, Charlotte quickly focused on the changes that had happened economically between her life as a student and a nurse. She used to plan for grocery shopping and make detailed budgets but has become unstructured in this regard as her priorities have changed: “*back then when we had no money we were really good at prioritising. I used to look in offer catalogs, do meal planning and all those things but it all just went out the window*”. She now values vacations with her family highly and describes how they will even take unpaid leave to go on long trips. Her economic values and behavior have changed dramatically with the change in her life situation – that is having kids and a reliable source of income. Charlotte values everyday financial insights because it makes her feel in control. She logs into her online bank daily to check up on transactions and make sure that everything is going according to the plan. She confirms that the correct amounts are withdrawn from her account for the purchases she makes and that her salary is deposited to her account. “*For example just an hour ago, I ordered some new clothes for the kids online and then I go to see how it is going [on the netbank] quite instinctively. I do this because i like to be in control of the situation*”. Although Charlotte checks her transactions daily she does not calculate her weekly or monthly expenses in order to adjust her spending behavior but rather makes the adjustment based on intuition after glancing through her transactions. This habit of adapting her spending behavior reactively based on intuition is a way for her to stay in control after she stopped making budgets and knowing exactly how their money was spent. Charlotte always uses her smartphone or iPad when interacting with her netbank. She leads a busy life so she goes online in quick sessions in between household tasks and as such fits her banking activities into the flow of her everyday life: “*I often log on at the kitchen table. I would say that i am almost never sitting in the couch. We lead busy lives, when the kids are put to bed I have to do the laundry for example and then I will often sit at the kitchen table for five minutes [on the netbank]*”.

2.1.3 Young Couple

Our last interview was a semi-structured with Hanna, a 25-year-old woman working as a physiotherapist, and her boyfriend, Christian, who used to work as a physiotherapist but now pursues a career as a pre- and middle school teacher. They live together in Aalborg which is located in Northern Jutland in Denmark. The interview was conducted via Skype with screen and audio recording and lasted approximately 50 minutes.

When asked to characterize their financial situation Hanna and Christian described it as shaky as they currently found themselves in a transitional phase in life with a fluctuating number of work hours and career change, yet they felt comfortable and in control. In contrast to Charlotte (from the previous interview), Hanna and Christian do not have a shared economy. They, however, have a number of shared expenses such housing costs and groceries, therefore they have set up an account for this purpose; they deposit a fixed amount of money every month and the shared expenses get withdrawn from there. Hanna hinted that this kind of solution kept them from arguing about financial matters: “*We deposit money each month for the shared expenses, so we don't have to discuss how much we [individually] have to pay*”. Later on in the interview, when asked how much time they spent on financial doings, Hanna underpinned this statement by saying that the subject of economy was perhaps not the most pleasant thing to talk about. Approximately once a week they go online to check up on their finances and they usually do this from an iPad or laptop. They make a quick glance at the transactions and from there go to e-Boks (an online mailbox used by the Danish government and some public/private companies) to cross reference with received bills and paychecks. By the end of the month the amount of financial checkups increases in order to make sure they stay within their spending limits. Christian told us he uses a Visa Debit card (a non-credit card) and when asked if it was a way to avoid overspending he responded “*Yes exactly – I am more comfortable with that.*”. Because of their varying income they sometimes have to borrow money from one another and to keep track of their financial outlays they use a whiteboard located in the living room. They also use a big calendar and notes to keep track of their finances. They use these low-level tools to remind themselves of economy related deadlines and to keep each other informed at all times.

2.2 Workshop

This section presents the exploratory workshop that we conducted to gather further information about people's financial habits and value-sets related to a domestic context and more importantly to obtain insights into how people would imagine future banking experiences to unfold; both in terms of functionality and interplay between the context and technology. The workshop was carried out in two parts. The first being a series of warm-up exercises and the second work with a self-developed kit, that we call Exploration Kit, which was designed to help participants explore and express their ideas.

The first half of the workshop was spent doing four exercises related to interactions with and feelings about economy. The point of these exercises was twofold; firstly it made the participants reflect upon their own economy in order to create a basis for ideation with the Exploration Kit and secondly it acted as a way to gain knowledge about the participants' attitude towards economy and usage of current banking tools. The second half of the workshop was assigned to work with the Exploration Kit. The purpose of the kit was to enable the participants to come up with ideas for banking experiences in the home. Importantly the kit forced the participants to not only think of an abstract concept but also how it could be physically manifested in the home context.

The workshop was conducted in the evening and had a duration of approximately 2 hours. Ten people participated in the workshop, seven of which were male and three female. The ages ranged from 22 to 27 and the majority (seven out of ten) had a cohabitant or lived together with one or more people. All of the participants except one were university students and a little more than half of the students had a technical background whereas the other half was less tech-savvy.

2.2.1 Warm-Up Exercises

In order to establish an inspirational atmosphere and spark creativity we conducted a series of introductory exercises. These exercises aimed to capture some general knowledge about the participants' background, technology usage and financial attitude. Many of the exercises were designed in the spirit of Gaver et. al's Cultural Probes [20] as they strived to capture data in a more inspirational and imaginative manner.

Chapter 2. Establishing a Direction



Figure 2.1: **Top left:** Some of the pictures created during the *Draw your economy* exercise. **Top right:** Floor plans created in the *Floor plan* exercise. **Bottom left:** Sequence of emoticons used to describe the emotional relationship with money in the *Emoticonometer* exercise. **Bottom right:** Ballot papers from the *Voting* exercise.

“Draw Your Economy”

We initiated the workshop with the task to “draw your economy”. This exercise was very much inspired by Kaye et al. [25, p. 522] and was intentionally very open as the participants were told they could draw whatever came into their minds. The goal of the exercise was to make the participants reflect upon their own economic situation in order for them to use this as a foundation for the later ideation with the Exploration Kit. Furthermore, it gave us insights into the participants’ mindsets towards economy.

The drawings can generally be divided into two categories. The first category contains abstract drawings that try to convey the feeling the person is experiencing in relation to their economy, e.g. a man standing on top of the world

2.2. Workshop

or a man struggling to find water in the desert (see figure 2.1 top left picture). The second category contains more concrete and diagrammatic drawings related to spending or the money flow, e.g. diagrams showing the spendings account balance over time or diagrams showing how the monthly income is spent in relation to different categories such as housing costs, leisure and groceries. Some participants combined the two categories to convey their general feelings or mindset about economy while also hinting at how they spend their money. One participant, who combined the categories, drew a person floating down a river (a stream of money) surrounded by food, gifts, clothes and so on.

The ways the participants think about economy and spend money are numerous. However, there is a tendency towards an either very positive or negative attitude regarding economy. Some participants portray their economy as struggling or unstable while others display joy and satisfaction. One participant drew himself on top of the world and explained that he was a big consumer and very deliberately purchased items related to his hobby which would result in positive emotional responses such as excitement or happiness. It was a common theme for people who had a positive attitude to focus on the possibilities and explicitly what made them happy. One participant valued holidays highly, another clothes and a third computer games and equipment. A participant with a negative attitude drew the Leaning Tower of Pisa and explained that he thought his economy was off balance because he did not care much about it and at times completely neglected it. Common for the ones with a negative attitude was the general dislike of economy as a subject and frequently neglecting it.

Floor plan

In order to get a better understanding of how people organize and interact with their economy in the context we asked them to draw a floor plan of their residence and place different markers, representing various technologies or mediums, on this floor plan. As financial information is accessible from many different platforms, it comes as no surprise that information is not strictly bound to specific artifacts or locations. The artifacts used ranged from simple paper and Excel spreadsheets to the more multipurpose smartphone. Looking at the floor plans created during the workshop it becomes evident that the increased portability in digital devices has altered the way we connect with our economy and shows that – even though we are not completely aware of it – financial interactions are more omnipresent than ever before. Most of the

Chapter 2. Establishing a Direction

participants used laptops, tablets and smartphones as a way to stay in touch with their economy, and no place in the home seemed to be “sacred”. The living room, kitchen and the bed seem to be most popular places to interact with economy, however only very few restricted their interaction with money to very specific places or rooms.

Emoticonometer

In one of the exercises we asked the participants to express how they felt about their financial situation. Inspired by the Smileyometer [36], we provided the participants with a set of emoticons and asked them to answer three questions, e.g. “how is your relationship with the bank”, using these emoticons. We decided to use emoticons instead of hand drawn smileys as we feel the average user, having varying drawing skills, will be able to express their emotional state towards economy more precisely. Also, since the emoticons embody a wider and more diverse range of emotions it can no longer be characterized as a traditional Likert scale. With this exercise we hoped to gain a better understanding of how people are emotionally engaged in different aspects of their economy and where there might be an opportunity for improvement. Based on the output from the workshop we see that people have mixed feelings about their economy (see figure 2.1 bottom left picture). The participants used very different emoticons for the same questions, however most of the participants used a somewhat positive emoticon to express their personal economy, whereas the topic of talking economy with others and the relationship with the bank were more diverse. This is very much in line with the first exercise where people drew their financial situation.

Voting

In the last exercise we asked the participants to fill out a ballot paper (see figure 2.1 bottom right picture) where they indicated any technology they had used to manage their personal finances on that particular day. This resulted in the following distribution:

- E-bank: 1
- Mobile e-bank: 3
- MobilePay: 5

2.2. Workshop

- Creditcard: 8
- Cash: 1
- WeShare: 1

A clear pattern emerges showing that the old “technology” in the form of cash is on the retreat while the well established credit card technology is still the most prevalent. However, we see a rise in the adoption of new solutions namely MobilePay and mobile e-banking, which resonates well with the current trends of digitization. In this regard it is important to take the participants under study into account particularly their relatively young age. While young people are known to adopt new technologies faster, we believe that it is also part of a general tendency towards more rapid technology adoption.

2.2.2 Exploration Kit

In the second part of the workshop we introduced our Exploration Kit (see figure 2.2) which has been inspired by Rodden et al.s ‘physical jigsaw editor’ prototype [39], where jigsaw pieces are used to build sequences as a way to compose various technology arrangements in the home. Our kit contains four main categories of pieces in different colors that are combined in a sequence and is meant to make the participants reflect upon various aspects of a new banking experience in a specific order. The categories are designed to help the participants to consider one part of the concept at a time instead of all at once, aiding them in the difficult process of coming up with new ideas and avoiding frustration or confusion. The first category *data type* is concerned with the kind of financial information or action that is desired e.g. transactions or savings. The second category *resolution* is regarding the resolution (level of detail) of the information that is manipulated; low resolution being simple information that is quickly understood but has limited information capacity and high resolution being complex information with unambiguous and detailed information. The third and fourth category is *input* and *output* respectively which deals with the modalities of the interaction and are intended to make the participants consider the physical manifestation and functionality of the concept by asking themselves questions such as *how do you interact with it and what is the outcome?* and *what should it look like and where would I like it in my home?*. Finally, the Exploration Kit contained two optional categories concerned with filtering and triggering

Chapter 2. Establishing a Direction

of information; filtering being sorting data or selecting specific information to be inspected in more detail and triggering as in deciding when and how information becomes visible. These optional categories were designed to be additional considerations that could be performed after the main sequence was built and the outline of a new banking experience made.

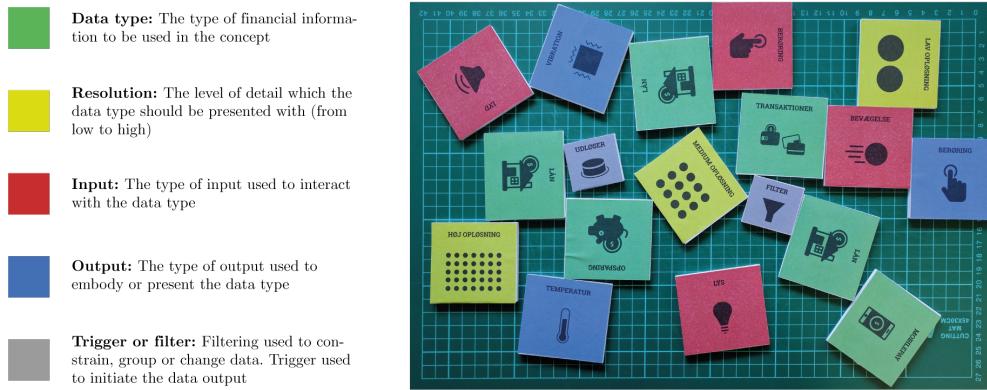


Figure 2.2: Overview of the exploration kit

Provotypes

The Exploration Kit was introduced to the participants along with two “provotypes” [8] that we created using the kit ourselves. These provotypes acted as an introduction to how the Exploration Kit should be used while also creating provoking thoughts on how financial technology in the home could look like. It was crucial for us that the provotypes were perceived as slightly odd or unconventional in order to instill a sense of creative freedom in the participants – it was perfectly acceptable and desired to come up with silly ideas. One of the provotypes we presented was a scale (see figure 2.3) to “weigh” financial transactions and get information on spendings in different categories. A cube with category-labels such as *clothes* and *transport* on the sides is placed on the scale to weigh the spendings in the category facing upwards. A bar on the scale indicates how much of the monthly budget that has been spent in the selected category, i.e. if the bar is 25 percent full it means 25 percent of the total monthly budget has been spent in that category. As stated we used the Exploration Kit in the creation of the provotype; the point of departure was the selection of transactions as the data type and

2.2. Workshop

a medium data resolution as we wanted the possibility to manipulate and explore the information to some extent. Thinking of the input category and consequently the interaction, we decided that touch or pressure would make for an interesting and alternative experience. Based on these constraints we started brainstorming on touch sensitive objects and interactive pressured based surfaces ultimately leading to the idea of a kitchen scale and the concept of weighing your economical transactions. Finally, we decided on light as an output in the form of a LED display that shows the relative spending in a given category.

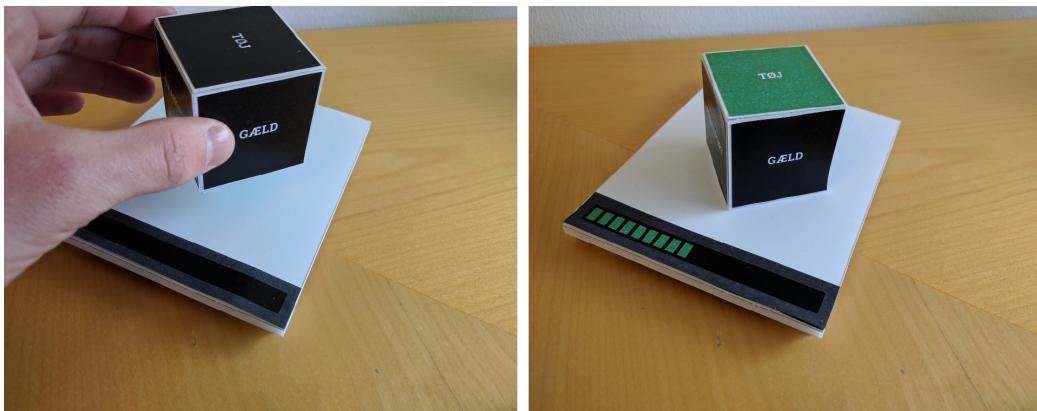


Figure 2.3: Kitchen scale prototype used to provoke and inspire the workshop participants

Working with the Exploration Kit

In order for the participants to be more expressive we provided them with an assortment of materials (pen, paper, balloons, play dough, etc.) which they could use to externalize their ideas. In average each participant created two ideas using the kit of which many reflected some kind of personal experience with economy.

One of the participants told us that he would often forget to read messages from the bank, therefore he envisioned a refrigerator magnet shaped like a one-dollar bill where a talking George Washington would read messages from the bank aloud (see figure 2.4 bottom right picture). Another participant also used an avatar-like data representation, however in a much more indirect and subtle manner. He imagined his finances represented as a fish in an aquarium

Chapter 2. Establishing a Direction

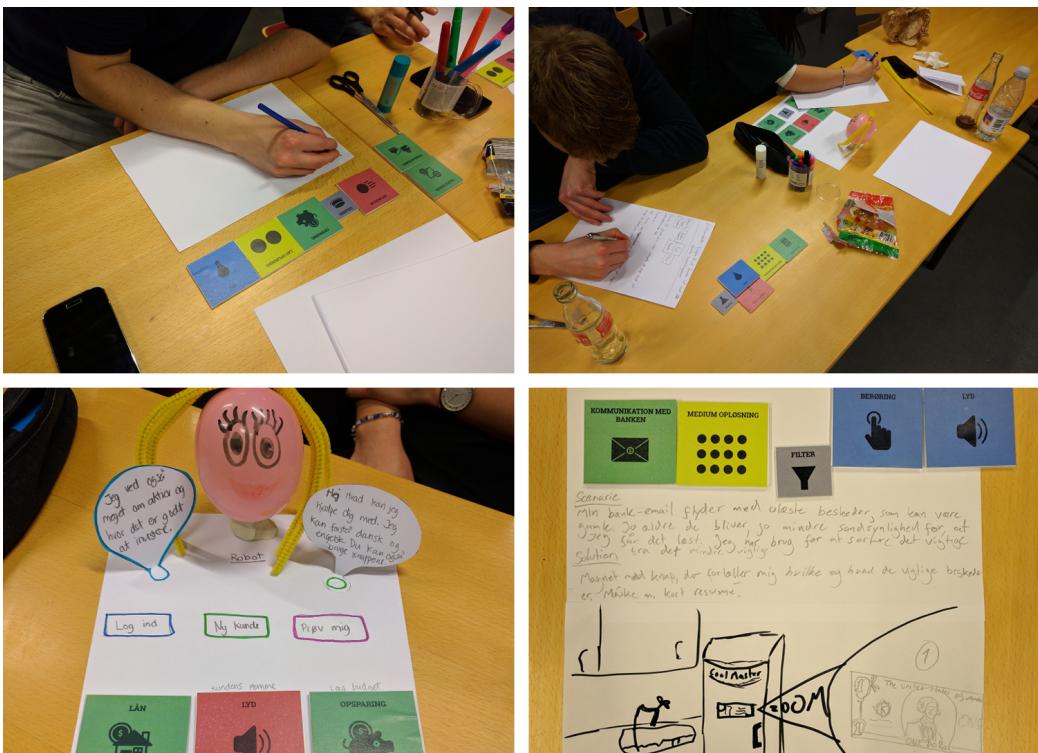


Figure 2.4: Top left and right: Participants working with the exploration kit. **Bottom left:** AI robot created by one of the workshop participants. **Bottom right:** Talking one-dollar bill concept created by one of the workshop participants.

and depending on the color and the behaviour of the fish as well as temperature and flow of the water would be able to infer the state of his finances. This idea stemmed from the fact that he spends many hours at a desk, therefore he pictured this kind of representation to be suitable and playful. Even though this kind of solution is simply an alternative representation of financial data, it will most likely induce a more reflective practice in relation to spending habits. One of the participants knew he would often spend money on what he called “stupid things” and therefore he designed a wallet with a built-in screen that would prompt him every time he bought something above a certain price tag. This type of enforced evaluation was not found among the other participants’ designs, yet some degree of quality assessment could be seen, e.g. represent financial status through colored light. A more radical design was an AI (artificial intelligence) robot with a multitude of functionality (see figure 2.4 bottom left picture) that was designed to replace

2.3. Data Analysis and Initial Findings

the current financial advisers. The participant felt this kind of solution was needed as she had no trust in banks or advisers, and believed that an impartial robot would give her the best financial advices. A different participant developed a concept that did not involve a physical artifact. He envisioned a solution where financial data could be linked to the lighting system of the house (e.g. Philips Hue). Triggered by bodily movement the system would then be able to convey financial information through color and light intensity. Another concept that ended up being a big inspiration for our exploration process was the idea of turning information on and off. The person behind this idea described how financial information would appear/disappear on her wall based on eye tracking. For her, economy is an extremely sensitive matter and therefore she wanted to be in complete control over the visibility of information being conveyed. A recurring theme for many of the ideas was simple data representations (low resolution). Almost all of the participants used low to medium resolution when describing their idea which indicate that comprehensive data representations are reserved for existing solutions such as netbank or other applications.

2.3 Data Analysis and Initial Findings

This section summarises and combines the findings from the preliminary interviews and the workshop into emerging themes that are of particular interest in the domain of financial management technology for the home. We discovered the emerging themes by looking for general tendencies in the data which was achieved through affinity diagramming. Affinity diagramming is a technique where large amounts of data is grouped based on natural relationships and is often used in contextual inquiry as a way to organize insights from field studies [7]. The affinity diagram is built bottom up by grouping similar findings and then labeling them, resulting in a structure that reflects the weight of the data rather than our own preconceived thoughts and ideas. We created an affinity diagram for the workshop and one for each interview after which we combined them into one coherent diagram by connecting different data clusters using strings (see figure 2.5). From the accumulated affinity diagram we derived some general themes that will be described in the following sections. Some of the emergent themes are equitable or related to the research areas presented in chapter 1 and therefore serve as a validation of the relevance in our domain.



Figure 2.5: Accumulated affinity diagram created based in the preliminary interviews and the workshop

2.3.1 Portability

The first theme is based on the interplay between the existing ecology of technologies and contextual behaviours (i.e. routines). As reported in the floor plan and voting exercises users utilize a wide array of tools when seeking out and managing financial information. Many of these tools (e.g smartphones or tablets) are portable and can be used at different locations in the home (bed, kitchen table, couch, etc.). This exemplifies that spatial freedom, more specifically the ability to undertake tasks anywhere, has become of high value among many users. Due to their portability many of these devices can be integrated into existing routines but can also provide a foundation for new ones. In the interview with Charlotte we found that she had created a routine where she would check up on her finances at the kitchen table in between household activities. The portability of her devices (smartphone and tablet) allowed her to integrate financial activities into her existing routines. The interview with Michael, the financial adviser, revealed that banks are constantly pushing new functionality to their existing applications as customers – especially young customers – expect much from the financial services provided by the banks. This shift towards customer empowerment through self-service also led us to believe that providing the users with portable financial technology that can be configured to work with

2.3. Data Analysis and Initial Findings

existing domestic technologies and routines serves as a promising direction for further exploration.

2.3.2 Seamless Context Integration

We found the theme of context integration to be recurring in many of the participants' ideas and concepts in the work with the Exploration Kit. In one of the more radical cases a girl wanted her financial information to be displayed on her wall but only when she glanced at it and was alone in her home. She found economy to be extraordinarily sensitive compared to other personal information and when asked to elaborate on the reasoning behind her idea, she responded: "*I want to make absolutely sure that I'm the only one inspecting my financial information. I think it is very private data that I don't want to share with anyone*". Her concept is highly motivated by privacy which explains her wish for the technology to be so integrated in the context that it is able to completely disappear. Other participants valued the aesthetic character greatly, that is, creating a concept that fit stylistically into their homes. Many participants achieved this by making concepts about Interactive Household Objects, i.e. making existing artifacts in their homes "smart"; one participant created a concept with a digitized fish tank where the health of the fish reflected the user's economic status. Another participant made a concept with a smart key hanger that would brief the user on their economic status as they left the home. These wishes to make the technology at home resonates well with the findings made by Hughes et al. [24] stating that the aesthetics are important for the technology to be accepted and integrated in the home. We find that designing for a seamless context integration can be a great way to obtain technology adoption and use, especially when designing technology that deals with sensitive data.

2.3.3 Daily Routines

Routines are commonplace in everyday life and they are especially prevalent in the domestic context. As described by Tolmie et al. [44] in the previous chapter, routines help us get through the repetitive tasks of everyday life by undertaking sequences of practical action without hesitation or mental effort. We see several examples of routinely behavior in both our interviews and the workshop. In the workshop one participant designed a key hanger to get briefed on his economy as he left the house. In this case, picking up the keys at a designated place before leaving the house is clearly part of a

routine that is performed to remember certain items. It made sense for him to augment this routine with information about his economic status, as he rarely checked up on his balance. He believed it would help him spend his money more rationally as he would avoid impulsive purchases when his balance was low. In the interview with Charlotte, a family mother, she reported how her banking activities were intertwined with household routines e.g. checking up on transactions in between tucking in the kids and doing the laundry. Christian and Hanna described how they routinely used a whiteboard as a way to coordinate their activities and keep track of their finances. We believe that our findings regarding routinely behavior in the home as well as the literature on designing technology for the home support routines as a theme for further exploration.

2.3.4 Data Representation

In many of the concepts developed during the workshop, simple data representations seemed to be preferred over more complex and detailed ones. A few of the concepts even had a more abstract nature (e.g. showing financial information through a fish and its habitat) which can be viewed as a way to govern sensitive data from the “outside world”. If information is encoded in such a way that the intended receiver – usually the person owning the data – is the only one who can make sense of whatever information is visible, then relatively sensitive data can be conveyed without compromising personal privacy. However, this places a higher demand on the receiver as he/she should learn to decode information and do so without too much mental effort. Another important point about the low to medium data representations is that data becomes more perceivable as less information needs to be conveyed. Keeping the information density low decreases the users’ cognitive load and consequently makes information more glanceable. As found in the interviews from the previous sections and the work done by Kaye et al. [25], users tend to engage with finances in very short time periods and when doing so, they make sense of their financial data by looking at transaction patterns and anomalies. Therefore a lot can be gained by working with the data representation in the context of economy.

Related Work

This chapter presents related work in the areas of Ambient Information Systems, Informative Art and Personal Informatics. First, the field of Ambient Information Systems is presented including a taxonomy consisting of four design dimensions that have informed many choices in our design process. Then, Informative Art is introduced with high emphasis on designing aesthetic objects for the architectural space that promote brief moments of attention and reflection. Lastly, work in the field of Personal Informatics with focus on self-reflection is presented.

Related Work

Findings from previous chapters about privacy, routines and context integration indicate that the field of Ambient Information Systems is highly relevant in designing interactive domestic technology for personal financial management. This is because these systems focus on blending into the environment and presenting information in subtle ways that can potentially only be understood by the owners of the systems. In this regard we find that Informative Art is a particularly good source of inspiration. Furthermore, we believe that knowledge about Personal Informatics (Quantified Self) and self-reflection is valuable to understand how we may better support economic awareness and as it is highly related to data representations, which is one of the discovered themes in the previous chapter.

3.1 Ambient Information Systems

Since the foundation of Ubiquitous Computing, thoughts of calmer and more environmentally appropriate and integrated ways of conveying information have appealed to researchers and designers. This is largely contributed to Weiser's visions about "calm computing" [45] where he describes technology that is able to shift to the user's attention when needed and otherwise stay calmly at the user's periphery. Different directions of research that built on Weiser's visions goes by various names such as "peripheral displays", "ambient displays" and "notification systems". These have all been brought together by Poussman and Stasko who propose the term Ambient Information Systems (AIS) for this overall body of work [35]. To understand the differences between these sub-domains one has to understand the underlying design motivations that informed them. The category of peripheral displays

3.1. Ambient Information Systems

is the broadest and contains systems that may appear in the environment, on a secondary or even primary computer display. Ambient displays are a subset of peripheral displays, that are highly motivated by aesthetic goals and aspire to convey a small number of information elements. Notification systems are motivated by divided attention situations, where work tasks can be either primary or secondary in their attentional requirements. In the case of secondary work tasks these systems can be defined as peripheral. AIS as a direction of study are defined by Pousman and Stasko to have specific behavioral characteristics [35]:

- Present information that is important but not critical.
- Able to move from the periphery to the focus of attention and back again
- Focus on tangibility and representations in the environment
- Undistracting subtle changes that reflect updates in information
- Aesthetically pleasing and environmentally appropriate

In designing AIS decisions must be made regarding how much information to display, the specific aspects or elements to depict and how to display it. In the context of these decisions Pousman and Stasko present a taxonomy consisting of four design dimensions that constitute the space of AIS [35]: *information capacity, notification level, representational fidelity and aesthetic emphasis*. This taxonomy is essential to our work as it has informed the design choices in our exploration of the design space. For this reason the four design dimensions of the taxonomy are explained in relatively high detail in the following sections.

3.1.1 Information Capacity

Information capacity is described as the number of discrete information sources that a system is able to represent. Some systems are only capable of displaying a single piece of information whereas others are able to display numerous or arbitrarily many. Pousman and Stasko call these pieces of discrete information “nuggets”. They argue that there is a design trade-off between space and time when considering information capacity. The information capacity of a display can be increased by expanding the space for information or by making the display transition through several views over

Chapter 3. Related Work

a period of time. A system that uses multiple views or loops through views is naturally rated as having high information capacity since there, theoretically, is no limit to the number of information nuggets. Systems that have low ratings are typically physical displays that are purposely built to convey specific information using few information nuggets.

3.1.2 Notification Level

The notification level describes the degree to which system notifications are designed to interrupt the user, which directly relates to the relative importance of the information being conveyed – the importance of the information should reflect the attention it demands. Pousman and Stasko base this design dimension on the work of Matthews et al. [32] who define five notification levels: *ignore*, *change blind*, *make aware*, *interrupt* and *demand attention*. These notification levels are grounded in attention literature that categorizes human attention into three types: *inattention*, *divided attention* and *focused attention*. Inattention means that objects do not call for conscious awareness but may still affect behavior. In divided attention, stimuli is perceived such that attention is distributed over several objects and in focused attention all attention is focused on a single stimulus. Change blind represents information of minimal importance that is displayed in a way to not affect conscious awareness, corresponding to inattention. Make aware portrays information of some importance that calls for some attention, corresponding to divided attention. Interrupt and demand attention represent important information that should capture focused attention, meaning that the user is distracted from his current activity to attend to the system. Furthermore, demand attention also requires the user to perform some kind of action to stop the alerting. Notification level can be considered as the ambience of the system; systems that focus on unobtrusive make aware and change blind notifications are at the core of the ambient information system design space, while systems that use the interrupt or demand attention levels are further from the core.

3.1.3 Representational Fidelity

Representational fidelity describes an ambient information system's display components and how data is encoded into words, sound, patterns and pictures. It can be thought of as the level of abstraction, where some systems portray the information being monitored very directly while others provide

3.2. Informative Art

purely abstract representations. Pousman and Stasko describe representational fidelity using the theory of Semiotics, which is the study of signs and their meanings. A semiotic sign consists of three core parts. The object is called the *signified* and is the physical thing or idea that the sign represents. The *signifier* is the representation of the object (the signified) and *sense* is the understanding that one arrives at from observing or experiencing the signified or the signifier. Semiotic signs can be *symbolic*, *iconic* or *indexical* which can be directly translated to different levels of representational fidelity (from low to high respectively). Symbolic signs correspond to low fidelity because they are abstract and require some kind of rule-following convention to understand e.g. numbers, language characters and abstract visual representations. Iconic signs have a medium representational fidelity as they contain some transparency regarding the signified object e.g. metaphors and drawings. Lastly, indexical signs have a high representational fidelity as they are directly linked to the signified object, for example photographs.

3.1.4 Aesthetic Emphasis

The last design dimension is aesthetic emphasis which focuses on the importance of the aesthetics of the system. Judging aesthetics is fundamentally a subjective endeavour which makes it unfit to objectively decide a system's aesthetic emphasis, therefore it is instead judged on the significance given to the aesthetics by the designers. High aesthetic emphasis is common when designing for visually pleasing displays intended to leverage the work of artists or for physical AIS that are often sculptural in their designs. Systems that are considered to be of medium aesthetic emphasis are those that are not intended to be art objects but are still explicitly intended to be seen as calm and visually pleasing systems. Lastly, systems that prioritise information conveyance over aesthetics are considered to have low aesthetic emphasis but they can still be calm and environmentally appropriate even though there is no explicit focus on aesthetic aspects.

3.2 Informative Art

In 2000 Redström et al. [37] presented the idea of Informative Art. They denote Informative Art as a combination of artwork and various objects/surfaces through which digital information can be presented. It is described as a type of slow technology, i.e. it promotes moments of attention and reflection, and

Chapter 3. Related Work

aims to “*augment a traditional notion of art objects, turning the given type of design surface into an abstract information display*” [37, p. 104]. By embedding small pieces of digital information into structures or compositions Informative Art strives to give invisible information, such as website traffic or e-mail activity, form through digital artwork. Since Informative Art is designed to occupy architectural space, very much like paintings and posters, and is viewed as an integrated part of the physical environment a high focus on visual aesthetics is needed. This focus on aesthetics can be found in Pousman and Stasko’s [35] article where they describe Informative Art, using their taxonomy, as having a relatively low information capacity, a medium notification level, a low to medium representational fidelity and a high emphasis on aesthetics. Also, as prescribed by the notion of AIS, Informative Art is a type of technology that is designed to support peripheral information. In relation to their notation about technological artwork Redström et al. uses a term called Amplified Reality. They describe it as “*the enhancement of expression or functionality of artefacts using technology*” [35, p. 105] where the central point is on the physical presence of artifacts and not on some superimposed digital information laid on top of the “real world”. In other words, it is about enriching the expression of the real world rather than enhancing the impression of it.

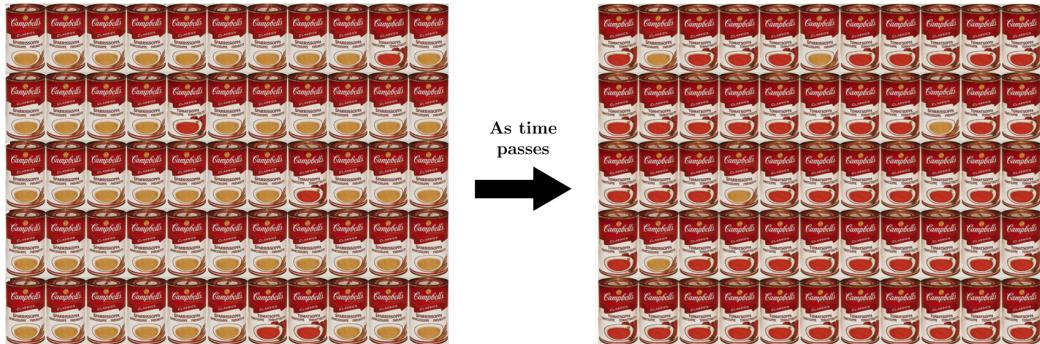


Figure 3.1: A countdown timer inspired by Andy Warhol’s paintings. Courtesy to [23]

In 2002 Holmquist and Skog [23] presented an Informative Art installation which was exhibit at the SIGGRAPH 2001 Emerging Technologies. Using a set of projectors, a laptop running various Java applications and white textile they depicted different types of data through artwork. One of the more interesting pieces of art was Soup Clock; a simple egg timer (see figure 3.1. Through a repeated pattern of asparagus (yellow) and tomato (red)

3.3. Personal Reflection

soup cans the passing of time was illustrated – in the beginning of time the graphic only shows yellow soup cans and as time passes a yellow soup can gets substituted with a red soup can. A decade later Fan et al. [18] attempted to use Informative Art to visualize personal activity using data from Fitbit (a personal activity tracker). Through a tablet, placed in a common space in the home, the participants could select between different types of abstract data representations (see figure 3.2) that pictured step count and intensity. When interacting with the system the participants could obtain more details like time for the exercise and exact step count. By the end of the paper Fan et al. presents three elements that seemed to motivate their participants, namely the use of color to indicate activity intensity, movement in the graphic and filling up the screen with graphic. All these visual rewards might also be applicable to our project.



Figure 3.2: Different data representations for Spark. Courtesy to [18]

For our work we find the technical implementation for Soup Clock very interesting as it can be used to augment an existing architectural space and thereby creates a sense of domestic “belonging”. Even though Fan et al.’s solution does not have a high emphasis on visual aesthetic – at least we do not view tablets as visually pleasing – there is something to be learned from their work on personal informatics and data representation. The work of Informative Art resonates well with our findings from the workshop, thus we have used it as a source of inspiration for our project.

3.3 Personal Reflection

As technology matures and becomes more ubiquitous the ease of gathering personal information grows. According to Li et al. many tools have been developed to utilize this data in order to support self-reflection, yet these tools do not seem to meet the users’ needs [29]. In previous work Li et al. described these tools using the term Personal Informatics systems which is

Chapter 3. Related Work

“systems that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge” [28, p. 558]. To achieve a better understanding of the problem space for Personal Informatics, Li et al. conducted a study where they set out to investigate what kinds of questions people usually asked about their data and why [29]. They identified the following six categories of questions: Status, History, Goal, Discrepancies, Context and Factors. Status refers to act of glancing at some data to determine whether or not a goal (e.g. drink two litres of water each day) has been met and if an action is needed to do so. History can be described as looking for trends and patterns in long-term data in order to get a sense of the overall progress (e.g. being on the path to achieve a goal or not). The third category, Goal, can be formulated in various levels of abstraction, however Li et al. use two types of goals, namely principle goal and program goal. Principle goals are related to achieving an ideal, for instance to become more productive, whereas the program-level goal represents a specific task which needs to be performed in order to achieve the principle goal, e.g. spend less time on social media. Discrepancies is somewhat intertwined with the Status category as it denotes the action of looking at the current status and then compare it with the goal, e.g. what is the difference between the goal and the current status. The last two categories, Context and Factors, are related to events or elements that in some degree influence the progress towards the goal. For instance, is food going to have an impact on the productivity.

In the pursuit of self-knowledge Li et al. found two phases to be prevalent. The first phase is the Maintenance phase where users have identified their goals and know which factors that have an affect on their progress. Users in this phase will often ask questions within the categories of Status and Discrepancy. The second phase is called Discovery and is characterized by a lack of goal and often users have failed to identify the factors that have an impact on their behaviour. People in this phase are asking questions regarding the History, Goals, Context and Factors. Depending on the phase different strategies can be applied to support the users, for example in the Maintenance phase it can be a good idea to alert the users when they are not meeting their goal.

As we are trying to develop an artifact for economic awareness an understanding of Personal Informatics is paramount. We aim to make use of the basic ideas presented in this section as we believe this will benefit our work greatly.

Exploring the Design Space

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Exploring the Design Space

4.1 Ideation

Prior to our initial brainstorming session we printed a set of pictures – each representing a specific quality, topic or idea related to our domain – that served as a source of inspiration. We spent approximately 30 minutes finding the pictures and used sticky notes and markers to annotate interesting elements. We generally used this method as a warm-up exercise and to establish a creative atmosphere, however it also underlined the importance of light, material and structure in the home. For instance, many of the pictures depicted how light can be used to highlight unique features of a room and that high quality materials are closely connected to visual aesthetics.

4.1.1 Brainstorming

In order to sharpen our focus and guide our brainstorming session we use the findings presented in section 2.3 as categories, i.e. technology arrangements, seamless context integration, daily routines and data representation. We performed four successive brainstorming sessions lasting around 30 minutes each and used sticky notes to externalize the different ideas. Once the four brainstorming sessions ended we “dotted” the ideas – i.e. accentuated ideas with high potential or with interesting features – with small pieces of paper. Lastly, we discussed the different ideas, considered alternatives or combined them if we found it relevant.

In the portability category the ideas varied greatly. Everything from a digital spray can which could be used to “paint” walls with financial information

4.1. Ideation



Figure 4.1: Annotated pictures used to stimulate creativity

to candles emitting smell and light to create an “economic atmosphere” was purposed. However, one of the most prominent themes within this category was configurability meaning that many of the artifacts could be adapted to different circumstances and people, and therefore we decided to investigate this direction further. In the seamless context integration category two main themes surfaced, namely augmenting the infrastructure of the home (walls, floors, windows, doors, etc.) and self-contained household objects (tables, chairs, wall clocks, etc.). One of the ideas within this category utilized natural light from a window to create a type of a shadow display that would reflect significant changes in the economy. A second idea was a type of financial clock that would display various financial interactions – we found this concept particularly interesting due to its strong connection to time. The ideas from the third category, daily routines, tried to weave financial data into ordinary routines. Especially morning routines seemed to be prevalent as many of the ideas depicted objects for a waking up or breakfast experience, e.g. a toaster



Figure 4.2: Outcome of the brainstorming session

burning financial information into bread or an alarm clock playing financial tunes. The fourth category, data representation, deviated slightly from the other categories as it mainly showcased different displays or mechanisms without specifying how they were connected to economy. It mainly consisted of physical moving structures that could be used to display information in varying levels of detail. Since this category did not contain any concrete concepts related to economy we decided not to pursue this direction with a specific prototype.

4.1.2 Three Possible Directions

As described in the previous section, the outcome of the brainstorming session was choosing three distinct ideas to pursue further, each with a strong focus on a specific emergent theme. The reasoning behind this was to discover which themes were most promising and significant in designing financial management technology for the home. Naturally each idea has connotations to other themes as they are intertwined to some extent but the ideas were chosen deliberately for their particularly apparent connection to the themes of daily routines, seamless context integration and portability, respectively.

4.1. Ideation

Two of the prototypes work explicitly with the subject of financial status because we found that users value knowledge about the status of their spendings and that it is strongly related to feeling economically aware. The three ideas will be presented briefly followed by an evaluation of the ideas with a group of former workshop participants.

Coffee Mug for a Morning Routine

The Coffee Mug prototype (see figure figure 4.3) focuses explicitly on providing a brief financial overview as part of a morning routine that many people have in common, namely drinking coffee for breakfast. The mug features a compartment in the bottom that is connected to the handle. This compartment is filled with liquid and contains a pressure system enabling it to regulate the liquid level in the handle. The liquid level represents the user's monthly spending budget with a full handle equating no money spent and an empty handle meaning that the monthly budget has been spent. The Coffee Mug, thus enables the user to get an approximate status of the monthly budget at a glance as part of his morning routine.



Figure 4.3: Coffee Mug prototype presenting a brief overview of monthly spending as a part of the morning routine

Financial Clock

Focusing on the theme of seamless context integration we chose to work with a clock as it is an object that is installed in the home and lives among the other household objects, thus being well integrated in the context. The Financial Clock prototype consists of a display that covers the entire dial, a center

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display and an interactive clock hand (see figure figure 4.4). One revolution on the dial represents the user's monthly spending budget. The dial is filled with slices, starting from twelve o'clock, that differ in size relative to the transactions they depict. The clock hand is placed on the bezel of the clock and rotates as on a regular clock but with one revolution taking a month instead of 24 hours. This makes it easy to spot whether the spendings are on track with the budget, as the transaction slices and clock hand should follow each other around the clock. The user can furthermore inspect the individual transactions by rotating the clock hand to point at the slice of interest. The transaction corresponding to that particular slice is then shown in the center display.



Figure 4.4: Financial Clock prototype enabling the user to get a monthly spending overview with indications of individual transactions that are inspectable by rotating the bezel of the clock

Financial Speaker

The Financial Speaker prototype (see figure figure 4.5) is a small portable speaker that can be arranged and rearranged as the user wishes, which allows it to be easily integrated in existing activities and routines in the household. The Financial Speaker uses a speech interface to interact with the user along with sensing technology to infer the user's presence. The prototype is configured through a smartphone application where the user chooses the financial information of interest and when to trigger it. For example, the Financial

4.1. Ideation

Speaker may be placed in the bathroom and configured to tell the user about relevant stock market information in the morning, when the user's presence is inferred. The user may at any time ask the Financial Speaker to provide information on another economically related topic or stop playing, as is regular functionality of speech interfaces.



Figure 4.5: Financial Speaker prototype that features a speech interface and is able to communicate relevant financial information to the user based on smartphone configuration and placement in the home

Evaluation of Initial Prototypes

In order to assess the properties of the three prototypes we performed a small informal evaluation, lasting around 25 minutes, with three former workshop participants. As described earlier each prototype represents a specific focus and for this reason we, with this evaluation, sought to understand what features and/or qualities each prototype could bring to our final prototype. The ideas were presented one by one followed by a series of open question, e.g. “what do you think about the data representation?” and “how would you use such an object in your home?”.

When we presented the Coffee Mug concept to the participants they seemed to like the simplicity of it, yet they were not sure if they would use it on a daily basis. When asked about the data representation one of the participants responded *“I think it is fine, because I don't need a specific number to know how much [money] I have left”*. Another participant pointed out that visualization of the data was, due the asymmetric shape of the handle, somewhat difficult to read and thus a bit ambiguous. Even though the data was showed in a low resolution format and presented relatively to a monthly

Chapter 4. Exploring the Design Space

budget, they did not like that information was visible to others. The second prototype we presented was the Financial Speaker. Compared to the Coffee Mug one of the participants liked that he had the initiative, meaning that he could seek out information and had some kind of control over the data. In his words emph “the information doesn’t need to be present all the time”. We asked the participants where they imagined to use such a product to which they responded in the bathroom, bedroom or office. One of the participants did not like the visual appearance of the speaker as he felt it looked too utilitarian. He told us that he considered buying the Google Home speaker (a voice-activated speaker created by Google) once it became available in Denmark because it resonates well with a home: *“it looks like it belongs there”*. All the participants generally liked the third prototype, the Financial Clock, especially because it provided a good overview and an intuitive interaction. However, the participants argued over the look of the bezel with the black clock hand. Two of the participants really liked it whereas the third one did not because it reminded him of an old telephone. Presenting a monthly view made sense to the participants as one (usually) receives salary and bills once a month. One participant suggested to divide the dial into four parts as it would become easier to view one week at a time.

To summarise this short evaluation, it confirmed that abstract data representations are something to pursue and that privacy is a topical area within our domain. Furthermore, the evaluation underlined that interactive household objects should stylistically align with the home in order to establish a sense of belonging – in other words, artifacts created for a home should be seamlessly integratable. Based on the feedback and our own designerly intuition we have chosen to work with the Financial Clock as it got great remarks from the participants while also presenting many possible design directions due to its relative complexity compared to the other ideas. Choosing this direction is an acknowledgement of the importance of context integration when designing domestic technology for personal financial management, as the Financial Clock prototype was centered around the emerging theme of seamless context integration. The decision to go in this particular direction has shaped our further design process as it provides the basis for our second research question: *“How can we design interactive domestic technology for personal financial management that is seamlessly integrated into the home?”*. The following sections present our effort to answer this question through iterative prototype development.

4.2 Prototyping

This section presents our further work and iterations on the Financial Clock prototype. First, we present some design guidelines that act as important considerations for our design choices, followed by design work that has acted as an inspiration in the design process, especially in relation to data representation and aesthetics. Then, we go into detail with the iterations on the prototype and present our design choices based on relevant literature and terminology, among these the taxonomy of Ambient Information Systems. Lastly, we elaborate on the notion that we call Emergent Displays which we believe is a promising way for interactive domestic technology to become truly integrated in the home and to ensure the privacy of sensitive data in this context.

4.2.1 Design Guidelines

Going from broad idea generation into more focused prototyping and iteration on the Financial Clock concept, we find it useful to keep some design guidelines in mind as we concretize the concept further. The guidelines are gathered from our own findings and the presented literature and essentially describe the factors that we have found to be important in designing interactive domestic technology for personal financial management with a focus on seamless context integration. The guidelines are presented in the following list along with a short description:

- **Aesthetics:** Emphasis on style and visual aesthetic. Artifacts designed with a high level of aesthetic emphasis have better opportunities to establish a sense of domestic belonging. Consequently, objects that are designed without attention to style and domestic properties have a lower chance to be integrated in the context.
- **Privacy:** The data should only be perceivable by the intended receiver and data should be protected from unauthorized persons.
- **Data Abstraction Level:** The level of data abstraction. Data embedded into and expressed through abstract shapes or structures has a high data abstraction level, whereas exact and detailed data has a low abstraction level.
- **Current Status:** The system should enable the user to view status;

preferably glanceable (low effort).

- **Data Persistence:** The data persists over time in such a way that trends and overall progress are detectable – this is comparable to Li et al.’s history category.
- **Data Inspectability:** The presented data should be inspectable to some degree, allowing the user to engage with the data (possibly in a serendipitous way).

These guidelines are not necessarily hard requirements that the prototype must meet but rather important considerations when we explore the design space further and make design choices as we move forward.

4.2.2 Exploring the Prototype Dimensions

In our exploration of the design space we use Lim et al.’s framework for prototype conceptualization, the anatomy of prototypes /citelim2008anatomy. This essentially means thinking of prototyping as filtering specific qualities of design ideas and manifesting them in the simplest way possible without distorting the understanding of the whole.

The following sections describe our explorations and design choices regarding the Financial Clock prototype. Design activities that we find are logically related are gathered and presented in sections together. It is important to note that this does not represent the actual order in which the activities were carried out, as many activities in reality ran in parallel tracks and informed each other in numerous ways.

Seeking Inspiration

As part of the design process we sought inspiration from various resources. Firstly, we found pictures online of elegant clock concepts and created a small collage out of them (see figure 4.6). What struck us the most about many of the clocks that we found interesting was their simplicity; both in terms of materials and of visual appearance. The vast majority of the clocks have a plain-colored clock face and express time in a very minimalistic manner. Three clocks that we found especially fascinating were Lash Clock by Bina Baitel, ETCH Clock by ETCH and STORY by Flyte [3, 17, 19] – each clock utilizes a unique technique to convey time. For instance, Lash Clock conveys

4.2. Prototyping

time through a ring of fibres and the ETCH Clock uses vacuum to create concave numbers on a flat surface. STORY is a bit different as it has three different modes. Using a levitating iron ball to depict time STORY can work as a normal clock, be a timer or show a journey, which essentially is a countdown timer linked to a story such as “time to next marathon”.

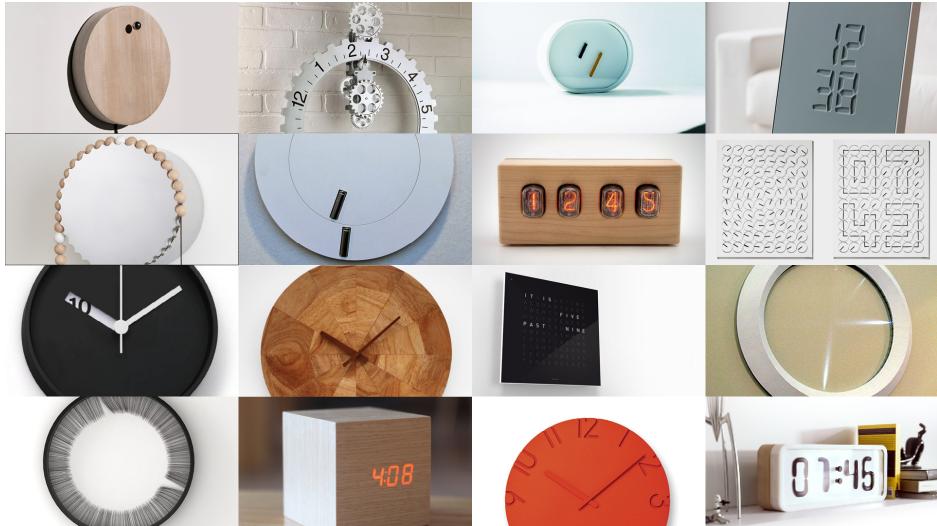


Figure 4.6: Collage of different clocks

Secondly, based on online research as well as previously encountered art pieces/products, we investigated similar and compelling concepts within our design space – some use the idea of a clock whereas others utilize an interesting technology. The Whereabouts Clock developed by Brown et al. [10] is a location awareness system for families. Using cell phone data the clock shows a symbolic location, such as “home” or “work”, for each individual family member. It aims to provide family members with reassurance, identity, connectedness and social touch. A more artistic clock is Last by Ängeslevä and Cooper [1]. It uses 1-pixel vertical slices from a video feed and three concentric circles (one for hours, minutes, seconds) to represent time; as time passes the clock “paints” with the 1-pixel slices leaving a trail of what has happened in the past (in front of the camera). Another project that we found great inspiration in is HEART BLOOM, which was presented at the Dutch Design Week 2016. Using bio-data and a pen plotter a circular pattern created from heart information is plotted on a piece of paper – the finished product looks a lot like a flower. This way of recording and presenting information we found very appealing. Lastly, BERG and Google made a project together where they augmented “dumb” objects by tracking and superimposing graphics onto them [6]. The quality of light and the graphical freedom this kind

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of solution brings was also something we found very interesting.



Figure 4.7: First: HEART BLOOM; Second: Whereabouts Clock; Thirds: Last Clock

Refining the Financial Clock Concept

Based on the inspiration from the previous section, we set out to define the overall direction for the Financial Clock concept, i.e. taking a step back and looking critically at the concept as it is presented in the ideation section. We decided to broadly investigate many aspects of the Financial Clock concept, including, among others, the numerous ways in which the user's financial data can be represented, interaction possibilities, physical form, and which technology to use as it has great implications on the opportunities and limitations regarding other aspects, such as interaction and data representation. We tried to be relatively open minded in exploring the possibilities of the Financial Clock concept, meaning that we did not explicitly use the design guidelines to constrain ourselves in the process but rather to analyze and evaluate the ideas iteratively.

The ideas presented in the following draw fundamental inspiration from AIS, specifically the idea that systems are able to reach out to the users and grab their attention in subtle ways instead of users having to actively seek out information.

Starting the exploration towards a concept with more explicit focus on seamless context integration we naturally took the Financial Clock concept presented in the ideation section (section 4.1.2) as a point of departure. While the concept in its initial form was created based on the theme of seamless context integration, we find that guidelines such as aesthetics, privacy and data abstraction could be addressed to further emphasize the theme. To address these guidelines we generated a handful of ideas (see figure 4.8). Many of these were intuitively focused on abstract data representations that were

4.2. Prototyping

either symbolic or iconic in nature as these make it harder for unintended receivers to perceive the financial information that is being conveyed, thus increasing privacy. Additionally, abstract representations may be recognized as aesthetically pleasing. One idea focusing on abstract representation was to cast a shadow up on the wall which resembled an eclipse. The eclipse would then gradually move corresponding to the user's spendings and thus act as a status overview. Ideas going in this direction move towards the Informative Art category where ideas become art with simple information embedded. While we find this direction intriguing due to the aesthetic emphasis and implicit respect for privacy caused by highly abstract data representations, there are still two guidelines left unattended; persistence and inspectability. Persistence is important because it enables the users to look for patterns in their long-term data while inspectability empower the users to engage with the data in more detail and look for discrepancies. Both of these guidelines are concerned with fostering self-reflection which is essential to our goal of increasing economic awareness, therefore they must be addressed.

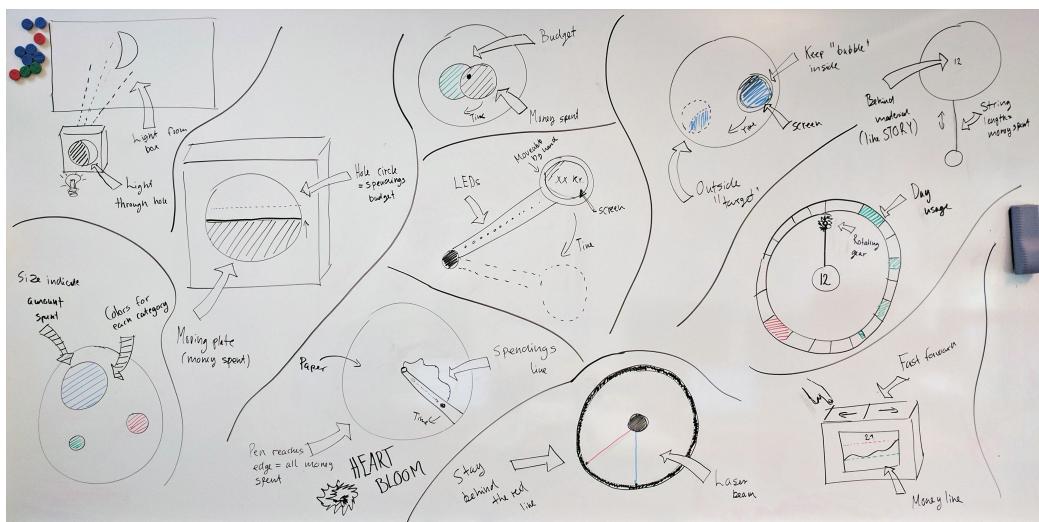


Figure 4.8: Picture of whiteboard sketches that explore the possibilities of the Financial Clock concept

One idea that provided data persistence was inspired by the HEART BLOOM project. The clock dial is covered with paper and the clock hand extends from the center to the bezel with a pencil attached to it. The pencil is able to move back and forth along the clock hand, creating a drawing that depicts the user's spendings over the course of a month. This idea allows the user to reflect on the history of his spendings but still lacks the ability

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to inspect any of the information. This is a common tendency we found in our exploration, ideas that only utilize mechanical movement have a hard time creating dynamic representations, which is required to properly support the design guideline concerning inspectability. In order to accommodate this guideline we decided that some kind of dynamic display was necessary. We worked with the idea of incorporating a screen display in some concepts but felt like it was not entirely in line with the domestic aesthetics and our direction towards seamless context integration, as most people choose to install only a couple of screen-based objects in their homes, namely televisions and computers for the sake of leisure entertainment. We reckon that few people would like to have screen-based objects spread throughout their homes as they are associated with the efficiency of the workplace and as such does not comply with the aesthetics of the home. Instead, we sought inspiration in BERG and Google's work on elegantly projecting graphics onto objects. What attracted us to pursue projection was the ability to retain the aesthetic properties of the object (e.g. shape and material) rather than sacrificing them for the utilitarian purposes of technology. This approach would allow us to design an aesthetic clock with a great sense of belonging in the home, however we still found that having a projected graphic on the clock all the time would be no less intrusive than having a screen-based object turned on all the time. Therefore, we decided to work with the notion of turning the display on/off based on sensing technologies such as proximity sensing, network activity or potentially even eye tracking. This particular idea gave rise to the concept we call Emergent Displays; displays that are able to emerge and augment household objects with information at moments when it is relevant to the user. The concept of Emergent Displays will be elaborated in a following section. Taking the direction of turning the display on at appropriate times implies that it will be in the off state most of the time as not to constantly interfere with the user's daily life. We believe it is important, especially in the case of a clock, that the designed object is meaningful in this off state in order to achieve a truly seamless integration in the home. Consequently, we decided that the Financial Clock should function as a regular clock in this off state. Essentially this means that the Financial Clock is able to switch between being a regular clock and a device for financial overview and inspection.

Summarising the Financial Clock concept after this exploration, we went in the direction of a multi-purpose device that can switch between regular clock and financial functionality in order to achieve a seamless integration in the home. Regarding the representation of the financial data, we found the idea of a drawing-like graphic that depicts the user's monthly spendings

4.2. Prototyping

interesting to pursue. Lastly, we believe that the form and interaction of the initial Financial Clock idea is worth keeping as the circular form elegantly affords the rotation interaction – the interaction naturally arises from the form, offering a novel interaction experience with a clock.

Clock Design

Now, with a more well-defined concept it is possible to “dissect” and explore the various design dimensions within our concept in a more focused manner. In this subsection we are going to present various investigations that we carried out in order to concretize the concept even further. In particular, we are going to use Lim et al.’s filtering dimensions, i.e. appearance, data, functionality, interactivity and spatial structure [30], as a means to answer questions such as “what kinds of material are suitable for projected light?” and “how should the user be able to engage with the application content?”. Furthermore, we are going to use previously presented findings and literature as guiding principles in order to refine different aspects of the concept.

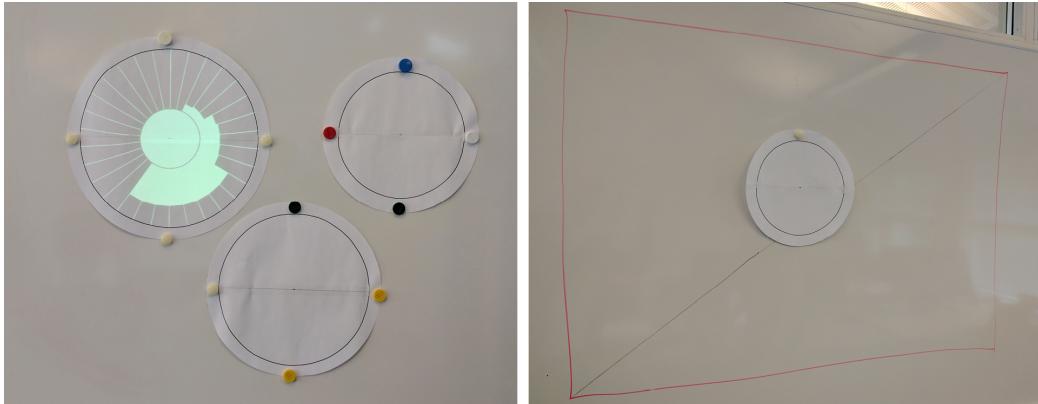


Figure 4.9: Exploration of the clock size

Having settled on the overall shape of the product (round like most wall clocks) our exploration into appearance began. In order to find a germane size for the clock face, we created a number of simple prototypes (see figure 4.9). The prototypes were manifested in paper, with a low resolution and small scope [30, p. 11]. The purpose of the clock size exploration was twofold; firstly we wanted to find a fitting size proportional to an average-size room and, secondly, as the size of clock face is equal to the dimensions of the interface surface – unless the wall around the clock is taking into use – the size

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of the clock face will have an impact on the information density. Therefore, choosing a suitable clock size is important in order to avoid a grainy and/or distorted picture. Our material exploration is very much based on BERG's video¹ about projection materials. They mainly investigated how white light behaves on different types of wood, thus we extended this experiment by using colored light on a wider range of materials (see figure 4.10). Perhaps not surprisingly, we found that in order to achieve an accurate graphical representation materials should be able to "absorb" light well. Also, when using colored light on dark/colorful materials, the colors of the light seem to be slightly distorted and less vibrant than on brighter materials. Consequently, we ended up using a somewhat light type of wood as we intended to represent current status through colors. For our last exploration into appearance we created an outline in Adobe Illustrator to iterate on the hour hand and the 3, 6, 9 and 12 markers. We decided to add the markers to the bezel due to earlier feedback (see section 4.1.2) but also to accommodate for the new clock functionality.

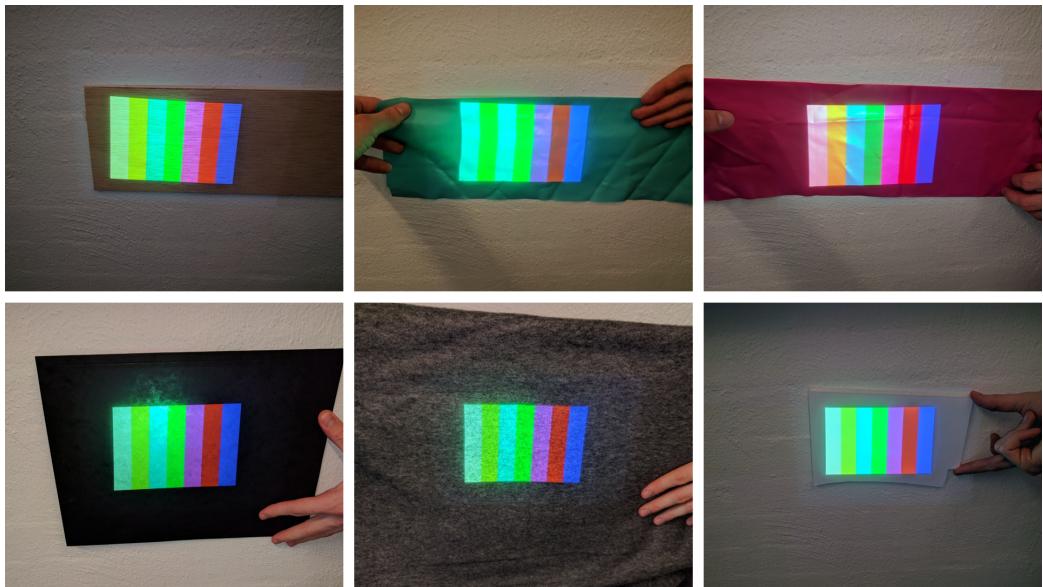


Figure 4.10: Exploration of different materials

In order to explore the inner workings of the prototype, i.e. the hardware and physical mechanisms, we created a prototype in foamcore (see the first and second image on figure 4.11). As we intended to investigate the functionality in detail we tried to keep the resolution high and the scope relatively

¹<https://vimeo.com/55536920>

4.2. Prototyping

narrow. We rather quickly decided to use a stepper motor for the rotating mechanism since this would yield, as opposed to a servo motor or DC motor, a high accuracy and a low noise level. As a result our design revolved around the dimensions and properties of a regular stepper motor. During our investigation we found that many of the mechanisms in our design rely on high precision and the foamcore prototype highlighted that we need to include some clearance (i.e. some distance between two moving parts) in our final design in order to achieve a functional fit. In relation to the interaction (moving the clock hand), one of the features that we really liked as designers about our initial prototype (figure 4.4) – and found to be a controversial topic among the people who evaluated it – was the physical manipulation of the bezel to “set time”. Even though we were very keen on this element we had to sacrifice it in order to preserve more indispensable features such as having a simple inner mechanics. For this reason we opted for an uncomplicated solution and ended up investigating alternatives. For instance, we enacted how various mechanisms from different standard hardware components (see third image on figure 4.11) would work in relation to the movement of the clock hand. One of the more appealing solutions was the rotation (found on for example a potentiometer and a rotary encoder) since it has a natural mapping to the rotation of the clock hand while being reminiscent of a crown found on regular wrist watches. However, unlike wrist watches there is no mechanical connection between the clock and the component meaning that the interaction could end up being perceived as disconnected and unresponsive. None of the other components offered something worth pursuing, so we chose the “easiest” solution, that is two buttons to control clockwise and counterclockwise rotation.

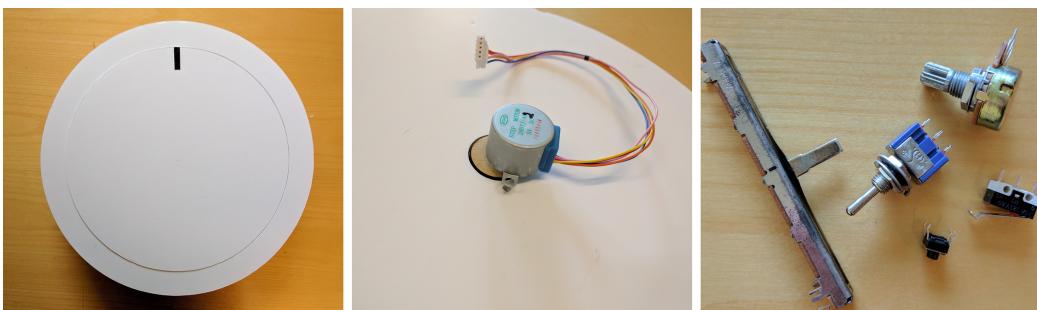


Figure 4.11: Foamcore model and components

Besides all the above-mentioned iterations, we had numerous iterations on the graphics and code, e.g. how to do projection mapping, how to correct

keystone, color schemes for the graphics, etc. We are not going to describe this in further detail, however some of the exploration into these aspects can be found on figure ??.

4.3 Emergent Displays

As described in section 4.2.2 our work with the Financial Clock concept led to an interesting combination of technologies, specifically projection mapping and internet-connected household objects, and we believe this combination can make for remarkable interaction experiences. Before we define the notion of Emergent Display we first need to establish a basis for it. We will start with a quote from Weiser and Brown on ubiquitous computing [45, p. 5]:

”

It is easy to find 40 microprocessors in a middle class home in the U.S.A. today. They will be found in the alarm clocks, the microwave oven, the TV remote controls, the stereo and TV system, the kid’s toys, etc.... Tie them to the Internet, and now you have connected together millions of information sources with hundreds of information delivery systems in your house

— Weiser and Brown, 1996

With such a reality new opportunities for systems arise. Being connected to the internet devices are not only able to fetch data like software updates, weather information or tasty recipes, they can also interface with other devices and be used to compose comprehensive systems consisting of multiple devices. For such a vision to be attainable devices must implement and expose a uniform interface to the “public”, making it possible for other applications (running on other devices) to make use of their resources, e.g. sensor data like light, temperature and orientation or output components like LEDs, servo motors and speakers. One way to achieve this universal interaction architecture is by creating applications with RESTful APIs [22]. This way of developing technology is going to be the technological bedrock for Emergent Displays – if domestic household objects make it possible for other applications to make use of their resources, new layers of technology can be added.

At its core Emergent Displays can be described as ephemeral displays that emerge on top of and/or around internet-connected artifacts making use of

4.3. Emergent Displays

their interactional features to apply secondary functionality. They are based on agile information carriers, such as shape change or projection mapping, meaning that a layer of information, i.e. the display itself, can dynamically emerge and disappear. For this reason Emergent Displays can be used to augment and enhance the expression of internet-connected objects while preserving their aesthetics qualities. In the context of Emergent Displays the meaning of ‘display’ refers to the temporary manifestation of information that once removed leaves the augmented object completely “untouched”. As described in the paragraph above the object being augmented should provide a set of interface “hooks” which secondary applications can make use of. For instance, a sunrise application can use events from an alarm clock to support and enrich the waking up experience or a countdown timer can be added to a toaster to show time left. An essential element in an Emergent Display is that once the information layer is added it should behave like an inherent part of the object, thus the coupling between changes in the emergent content and interaction needs to be tight. Also, applications utilizing this type of display should respect the physical properties and limitations of the augmented artifact. An underlying assumption about Emergent Displays is that the augmented object should make sense in all states, i.e. the object should be able to serve its original purpose and make sense while being augmented. One of the big questions when using this type of display is when the information layer should occur. One approach would be to use the resources (sensors for light, distance, temperature, etc.) from the augmented object, however it would also be possible to use resources from other devices/systems (security camera, door bell, etc.).

It is apparent that the domain of Emergent Displays is closely related to the research domain of AIS as it is inspired by the same vision of calm and environmentally integrated technologies which can enter the center of the user’s attention when needed and otherwise stay in the background. Emergent Displays and AIS share some fundamental behavioral characteristics such as a focus on representations *in the environment* that are *aesthetically pleasing* and environmentally appropriate. However, they deviate on *when* the information, that the systems convey, is present in the environment. In AIS information is always present (ambient) with subtle changes that afford opportunistic glances. An Emergent Display on the other hand only presents the information when it is deemed necessary or appropriate, which we have argued may give a greater sense of belonging in the context. Considering the character of the data we believe that Emergent Displays may be useful to address information of greater importance/sensitivity (such as financial data) since the information is displayed on the terms of the users and other-

wise hidden. Another significant difference is the focus on interaction with the information in our notion of Emergent Displays, which may provide a deeper level reflection about the data – AIS is primarily concerned with conveying information. The obvious current challenge for Emergent Displays is the dependence on sensing technologies to infer when the display should emerge and disappear. However, we strongly believe the challenge will diminish as more UbiComp technologies appear and together will be able to infer more complex behavioral patterns. Even though sensing technologies may be a challenge they also provide the opportunity for users to configure and arrange when and under which circumstances the display should emerge.

4.4 Final Prototype

This section briefly summarises the developed Financial Clock concept that is the outcome of the exploration described in the Prototyping section and then presents the technical implementation of the concept.

4.4.1 The Final Prototype Concept

The Financial Clock looks like a regular round wall clock with a simplistic design in wood that arguably fits into a broad range of people’s homes (see figure figure ??). While functioning as a regular clock most of the time, it will react to the user’s proximity upon which a display of the user’s monthly spendings emerges on the dial. This spending graphic consists of a line that moves clockwise around the clock as the days pass (one revolution corresponding to one month) and towards the bezel as money are spent. The spending graphic is colored in nuances of green, yellow and red depending on the spendings and the user’s budget, with green meaning that the current spendings are on track with the budget and red indicating overspending. Spendings on any particular day can be inspected using a controller device, that rotates the dial, placed just below the clock. When rotating the dial with the controller device, the clock hand acts as an indicator showing which day is being inspected with the corresponding transactions displayed in the center of the dial. If multiple transactions are present on the same day, they will be shown one at a time using a smooth fade animation. Once the user stops interacting with the clock and leaves, it will rotate the dial, and thus the clock hand, back to the position indicating time of the day and turn the display off returning to the state of a regular wall clock.

4.4. Final Prototype

A video showcasing the implemented prototype can be found at the following link: [LINK](#)

4.4.2 Technical Implementation

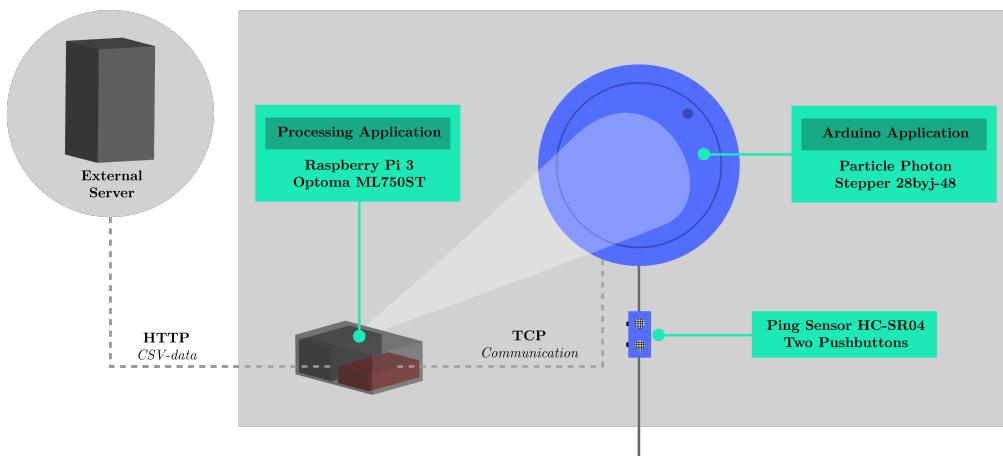


Figure 4.12: Figure showing the technical implementation of the Financial Clock concept

The Financial Clock prototype consists of two main parts; one part being the physical clock and the other a projector with a mounted Raspberry Pi (see figure figure 4.12). The clock was laser cut from plywood in a circular shape with a diameter of 31 centimeters. Within this, the rotating dial was laser cut with a diameter of 25 centimeters. A small box containing a photon processor and a stepper motor was attached on the back of the clock with the stepper motor connected to the dial, allowing it to rotate smoothly with a granularity of 2048 steps per revolution. The clock is connected to a controller device, placed approximately 30 centimeters below it, through a cord. The controller device is equipped with two buttons on the side that rotates the dial clockwise and counterclockwise respectively as well as a HC-SR04 ping sensor used to make the display emerge when the user is in the proximity. The projector used to augment the clock is an Optoma ml750st with a WXGA resolution of 1280 x 800 pixels. This projector is small and portable with a short throw lens that enables it to be placed closely to the clock, which is preferred considering the prototype must be deployed in the homes of users where it is impossible to mount it in the ceiling, which we

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believe is the optimal placement, due to the inconvenience it would cause. On top of the projector is a Raspberry Pi 3 Model B that is connected to the projector via HDMI. The Raspberry Pi runs a Processing application which creates the graphic display that is projected onto the clock. The position of the display is manually calibrated upon setup of the prototype using the arrow keys, with the possibility to warp the display through corner pin keystoneing, meaning that the projector can be positioned at an angle if needed.

Both the Raspberry Pi and the Photon are internet-connected devices that communicate using the TCP protocol. The Photon sends commands to the Raspberry Pi, telling it to turn the display on/off based on proximity sensing and interaction with the controller device. Furthermore it informs the Raspberry Pi to update the display according to the day the user inspects with the controller device. Finally, the Raspberry Pi continuously requests a server for the user's latest financial data and updates the display when new data is available. In the current implementation we must manually retrieve the user's data and upload it to this server as it is extremely difficult to automate this process due to the restrictions on sensitive financial data.

Field Studies and Evaluation

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Chapter 5. Field Studies and Evaluation

Field Studies and Evaluation

Discussion

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Chapter 6. Discussion

Discussion

Conclusion

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Conclusion

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Interviewguide

Introduktion

- Vi er studerende på kandidaten i IT-produktudvikling fra Aarhus Universitet og skriver speciale med Danske Bank. I den forbindelse kunne vi godt tænke os at vide noget mere om folks indstilling til og håndtering af privatøkonomi.
- Formål: se formålsafsnittet
- Etiske spørgsmål: Spørge om det er okay vi optager (video/billeder/lyd); data indsamlet i forbindelse med dette interview vil blive anonymiseret, og er kun anvendt til internt brug.
- Deltagelse: Det er muligt at trække sig fra interviewet når som helst eller undlade at svare på enkelte spørgsmål. Eventuelt opfølgende interview?

Opvarmningsspørgsmål

- Hvad hedder du?
- Hvor gammel er du?
- Hvor mange år har du arbejdet som kunderådgiver?
 - Har du været i andre banker før Danske Bank?
 - Forskelle mellem DB og andre?
- Kan du fortælle lidt om, hvad en normal arbejd dag består af?

Hoved-interview

- I hvor stor en del af dit arbejde er du i kontakt med privatkunder?
 - Hvad drejer henvendelserne sig oftest om?
 - Hvor ofte tager du/i kontakt til kunderne? Hvorfor?
 - Hvilken kommunikationskanal bliver oftest anvendt?
 - Fordele/ulemper
 - Hvad foretrækker du?
- Hvad har den teknologiske udvikling betydet ift. jeres [kunderådgivere] arbejde?
- Hvad er en god kunde i dine (som privatperson) øjne?
 - Er det også en god kunde i bankens øjne?
- Hvad mener du, at grunden er til, at nogle folk har svært ved at styre deres økonomi?
 - Hvilke former for strategier anvender de?
 - Hvad anbefaler/gør i for at hjælpe dem?

- Hvad er oftest vigtigt for folk ift. deres økonomi? (en god opsparing, investeringer, spare for at bruge mere på én gang, etc.)
- Baseret på din erfaring, hvordan har de fleste kunder det med banken?
 - Har de ofte brug for hjælp?
 - Hvad har de oftest brug for hjælp til?
- Praktisk: Hvordan administrere folk oftest deres konti?
 - Antal konti
 - Hvad bruger folk oftest flest penge på? Hvad er vigtigst for dem?
 - Inddeling
 - Fællesøkonomi
 - Hvad er vigtigt i denne forbindelse?
 - Fordele/ulemper
- Hvilken information vil du mene er vigtigt for kunderne på et daglig basis? (saldo, aktier, investering, etc.)

Afslutning

- Har du noget, som du gerne vil tilføje her til sidst?
- Har du nogen spørgsmål?

Interviewguide

Introduktion

- Vi er studerende på kandidaten i IT-produktudvikling fra Aarhus Universitet og skriver speciale med Danske Bank. I den forbindelse kunne vi godt tænke os at vide noget mere om folks indstilling til og håndtering af privatøkonomi.
- Formålet med interviewet er at undersøge hvordan folk håndterer deres økonomi i dagligdagen og hvilke økonomiske aspekter der er vigtigst.
- Etiske spørgsmål: Spørge om det er okay vi optager (video/billeder/lyd); data indsamlet i forbindelse med dette interview vil blive anonymiseret, og er kun anvendt til internt brug.
- Deltagelse: Det er muligt at trække sig fra interviewet når som helst eller undlade at svare på enkelte spørgsmål. Eventuelt opfølgende interview?

Opvarmningsspørgsmål

- Hvad hedder du/i?
- Hvor gammel er du/i?
- Hvor er du/i opvokset?
 - Hvornår flyttede du/i?
- Hvad arbejder du/i med? Hvor er du/i ansat?
 - Kan du/i fortælle lidt om hvad dit/jeres arbejde handler om?

Hoved-interview

- Hvordan vil du/i beskrive din/jeres økonomi? (med tre ord)
- Hvordan er dit/jeres forhold til økonomi?
 - Bruger du/i meget tid på at engagere dig/jer i økonomi?
 - Hvor lang tid? (om ugen/måneden)
 - Kan du/i lide at tage stilling til økonomiske spørgsmål?
 - Hvorfor? Hvorfor ikke?
 - Er økonomiske spørgsmål ofte grund til bekymring?
- Interaktion med økonomien i hverdagen (**observation**):
 - Hvilken bank har du/i?
 - Bruger du netbank (laptop/computer)?
 - Hvor ofte logger du ind på din netbank?

- Hvad bruger du typisk netbanken til? Hvilke opgaver?
(betal regninger, overblik/status, overførsler, investeringer)
- Hvor befinder du dig når du bruger netbank?
- Hvornår på dagen?
- Bruger du mobilbank app'en?
 - Hvor ofte logger du ind på din mobilbank?
 - Hvad bruger du det typisk til? Hvilke opgaver?
(betal regninger, overblik/status, overførsler, investeringer)
 - Hvor befinder du dig når du bruger mobilbank?
 - Hvornår på dagen?
- Bruger du MobilePay?
 - Hvor ofte bruger du MobilePay?
 - Hvad bruger du det typisk til?
 - Overførsler til venner, betaling i butikker, køb online?
- Bruger du den fysiske bank filial?
 - Hvor ofte?
 - Hvad bruger du den fysiske bank til?
- Bruger du andre værktøjer til at håndtere din økonomi? (excel, noter, etc.)
- Hvornår? Bestemte dage eller tidspunkter? (ift alle ovenstående)
- Hvor lang tid bruger du/i på de forskellige aktiviteter? (ift alle ovenstående)
- Snakker du/i med andre om økonomi?
- Finansielle aspekter:
 - Er det vigtigt for dig/jer at spare op?
 - Til hvad?
 - Hvordan sparar i op? Hvilke strategier bruger du/i?
 - Hvorfor er opsparing vigtig/ikke vigtig for dig?
 - Er det vigtigt for dig/jer at investere?
 - Hvad investerer du/i i?
 - Hvad er formålet med investeringerne?
 - Er det vigtigt for dig/jer at have løbende overblik over økonomien?
 - Hvordan får du/i overblik?
- Hvordan er dit/jeres forhold til banken?
 - Er du/i tilfreds med dette forhold?
- Snakker du/i privatøkonomi med andre?

- Hvor sensitivt er viden om dine/jeres økonomi i forhold til fx bekendte, venner eller familie?
- Har du/i fællesøkonomi?
 - Hvilke dele er jeres økonomi er fælles? Hvorfor?
 - Hvem har det primære ansvar?
- Afslutning på interviewet og introduktion til cultural probes (ved fysisk møde)