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Sally: *Your* Smart Home Ally

Developing an inclusive and tangible smart home interface

Master's thesis in Industrial Design Engineering

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DIVISION OF DESIGN AND HUMAN FACTORS

CHALMERS UNIVERSITY OF TECHNOLOGY
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“Women and technology don‘t mix.”

"There, we said it – and now we feel a bit awkward, because who actually says that anyway? Probably not women… However, this cliché has been around for so long that many women are starting to believe it themselves. As a result, technical gadgets have long been marketed as “boys’ toys”. Women are “allowed” to use these gadgets once men have explained how they work. It is high time for manufacturers to take a more inclusive and, more importantly, modern view of their target group."

Woman working for smart lock company Nuki

Preface

The aim of this project I twofold. It aims to develop a smart home device that is profitable and desirable for all, but also to raise awareness of the much prevalent gender gap across all fields of design and society. This is not only unjust, but also makes us develop products that are far from their potential, products that could support a better tomorrow by being more sustainable and inclusive. Or just with increased usability, better suited for its users. As Caroline Criado Perez (2021) says in her book 'Invisible Women':

"What happens when we ignore half of humanity?"

Taking the dutch design method Vision in Product Design (Hekkert et al., 2016) to heart where authenticity, responsibility, and freedom is key for making meaningful and novel designs, I hope to develop a product that makes the smart home experience better for women and everyone else. But, as a caucasian man of 186 cm and 75 kg, I am the so called reference man. The type of person most products are designed for by default. Entering a domain that is not my own, I think it is important as designers and humans to step outside of our own little world and try to learn and appreciate others, their cultures and experiences.

Simon Dybeck

Abstract

The amount of connected devices in our homes are increasing each year (Steward, 2022) but integration between systems are lacking; most interactions still done through apps. One big trend is the wish to reduce screen time (Barr, 2019) as smartphone use impedes mental well-being, especially for young girls (Abi-Jaoude et al., 2020). Additionally, each smartphone pickup to control the home can set off a chain reaction of phone use (MacKay, 2020). Also, statistics say that smart products are mainly bought and used by men (Zaman, 2021), leaving smart homes not designed for the needs of women (Strengers, 2015).

To combat the current smart home situation where most of the interaction is based on apps, a tangible device was developed. Addressing gender-bias issues by developing for women, this project shaped a smart home interaction concept that is more appropriate for todays trends and developments - making the smart home experience better and more inclusive.

Initially, insights were gathered through research on the smart home context, followed by surveys and user studies with women. Using the Vision in Design method (Hekkert et al., 2016), a vision was set to guide the project: Interacting with a smart home should be easy, quick, and delightful; just like the experience of actual smart products are.

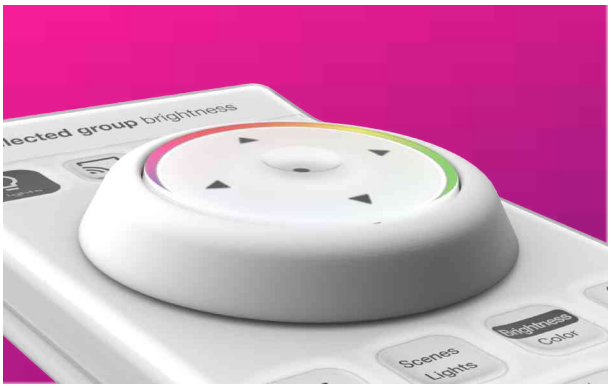
By evaluating common interfaces for controlling lights, audio, streaming, and comfort-related products like thermostats in the smart home, a novel interaction design was developed to allow for easy and quick control of heterogeneous connected devices. A digital interface was designed, prototyped, and tested with experts and users, achieving a System Usability Score of 78. The interface was then enhanced with physical buttons, a knob, and dynamic displays to provide a more tactile and delightful interaction experience than the common smartphone apps present today. Lastly, an Arduino prototype was built and tested with users, giving the concept a positive outlook for future development.

Keywords: smart home, remote, device, tangible, tactile, interaction, interface, gender-bias, inclusive, usability, distraction-free, concept development, user experience, UI, UX.


17:46
Lights
Stream
Comfort
Other
All devices off
SALLY


Living room color
Lights
Stream
Comfort
Other
SALLY


Choose streaming service
Lights
Stream
Comfort
Other
Music
Spotify
TIDAL
HBOmax
NETFLIX
Disney+
SALLY


brightness
Brightness
Color
Scenes
Lights

The final concept

Sally, your smart home ally, makes it easy for new or experienced users to control all smart home systems at the tip of their fingers. Its simplicity, familiarity and self-explanatory nature brings confidence to users, creating a bond of trust between the smart home and its inhabitants. Instead of dreading tedious and distracting smartphone use, the tactile remote makes controlling the smart home quick and enjoyable; the pleasant feel of every interaction enhancing the users experience of the smart home.

The opposite page shows the product and its dynamic use; blank when not used (upper left), light control (upper right), and streaming control (middle right). Close ups showing the combined directional pad and knob (bottom left), and the dynamic and tactile button grid (bottom right).

For more details about the concept refer to section 5.1.5.

Table of Content

1.

Introduction

This chapter explains the background, aims and objectives of the project, research questions, and related work about the smart home context.

1.1 Background

Smart homes - an ecosystem of smart products - are becoming more and more popular. Smart products being devices connected to the internet to share information about itself or its environment ("What Are Smart Products?", 2022) aimed to make life at home more convenient, and sometimes with added health benefits. Common smart products provide control of lights, heating, and electronics ("Oxford University Press", 2022) – manually or automated through scheduling or by triggering events like a window being opened ("Assistant", 2022). The benefit of having such automations and the increased capability for users to control the home from a convenient location, is that the home environment can be better regulated to fit with the users need for comfort, security, and moments of relaxation. One popular use of smart lights for example, is to set them to gradually increase and decrease the brightness in the morning and evening to aid users in following their circadian rhythm to wake up and sleep better (Hteny, 2022). Some even say that smart homes have everything to do with our health as those systems affects our desires and routines in everyday life (Pillan and SaraColombo, 2017).

Smart homes have been around for decades, but first gaining traction 10 years ago, introduced to the market by the release of the smart thermostat Nest in 2012 ("TechCrunch", 2013). In the same year Philips Hue released their famous smart lights, being one of the most common products users have in their smart homes today (Wikipedia contributors, 2021). A few years later both Sonos and Amazon released smart speakers, some models including voice control. Although voice control has become hyped in recent years (Woźniak, 2019), it is far from the most common interface option for controlling the smart home.

Some smart home owners have remotes, often dedicated to either controlling lights or a smart TV. Mostly though, users control their home through an app on a smartphone. Although the app in isolation often works well, the number of smart home devices are increasing in households, forcing the user to use a variety of apps for controlling each different smart home system. Some, like the dutch company Homey, have tried to combat this by providing a so called 'hub' that integrates all systems so the user only needs one app for control. This idea of a simplified and unified interaction is something users have asked for a long time which is why a conglomerate of Apple, Amazon, Google and other big tech companies are collaborating to release the unifying protocol Matter in 2022. This protocol will make sure that all smart products, no matter the brand, can communicate with each other, thus providing a way for users to more easily control everything from one app. Still, the lack of this possibility in previous years combined with subpar usability (Cho and Choi, 2020) slowed down smart home industry growth by a lot - 33% ("Statista", 2022) instead of the projected 43% for 2022 ("IoT Business News", 2022).

Another important factor is the lack of smart home development to be inclusive, to be used by women and men alike. Even though households comprise both men and women, the smart home industry have targeted tech-savvy men from the beginning, and still is (Strengers, 2015). The male dominated design industry ("Coroflot", 2022) continuously

develops products and services that adhere to the needs of only a small part of possible users - no matter the industry (Perez, 2021). It's not only unethical, but also limits the possibilities for smart homes to become common place and to provide its benefit in a way that it supports both the men and women of households. Even in multi-gender households that have smart products, there are issues where men more often know how to control these systems - sometimes used to abuse women by controlling locks, doors, lights, etc (Bowles, 2018). With rising awareness of gender-bias in our society, there is also a movement to reduce our screen time and dependance on our smartphones as it is proved that excessive use impedes our health (Cohen, 2021). It is also known that companies like Google and Facebook strive to make users addicted, stuck, scrolling through their apps hours on end ("NPR", 2018). Even though users try to reduce their screen time - 2019 seeing the cellphone box, a box for putting your phone away to not be distracted, as the Christmas present of the year in Sweden ("HUI", 2019) - large corporations still design app-based smart home interfaces as they know that each time we need to control something on our smartphone, it sets of a chain reaction of further use (MacKay, 2020).

Hence, my project aims to bridge the gender gap by providing an equal opportunity for inhabitants of all genders to control their smart home in a convenient and simple way so that users can reap the health benefits of smart home products. To reduce our dependancy on the smartphone, a tactile device is to be developed that adheres to the needs of women - highlighting the gender gap issue, but also to bring a fresh perspective for a market that lacks usability and simplicity. The project focus is to understand what women require from a tangible smart home interface and how such a device could be developed to be efficient and easy to use. Also exploring how such a concept can be materialised to provide an interaction that differentiates itself from the common use of apps, providing an experience that is tactile and delightful for new and current smart home users.

1.2 Aim and objectives

The aim of the project is to develop a tangible interface, as an alternative to the smartphone, to be more desirable to use for common smart home control. The device should be appropriate for the interoperability of smart homes. The device should also provide a more positive and delightful experience for users. The project is based on the needs of women who generally are overlooked in product design - also because women represent a huge potential market within smart homes. The objectives of the project are:

- Exploring women's concerns in the smart home context to help develop an appropriate interface for achieving common smart home goals intuitively and quickly.
- Developing a user interface with improved usability to be embodied in a tactile device with increased efficiency and effectiveness compared to smartphone interactions.
- Build a functional prototype with emphasis on delightful interaction for smart home control to be more experiential, tactile and appreciated by users.

1.3 Research questions

- What do women, conscious about their smartphone use, require from a tangible device to make it a preferred option for achieving common smart home tasks?
- How can a tangible device be developed to achieve common smart home tasks more efficiently and effectively than using apps?
- How can interaction with the tangible device provide increased visual, auditory, and tactile satisfaction compared to smartphone use?

1.4 Related work

This section explains the smart home context and its issues further.

1.4.1 Evolution of the smart home market in Europe

In the late 2000s, the men behind the iPod shared some thoughts over lunch, one of them saying: “I want to build a smart home company.”. The other one replying, “You’re an idiot. No one wants to buy a smart home. They’re for geeks.” ("TechCrunch", 2013). The to-be former Apple executives then started Nest in 2012 to provide people with a smart and good looking thermostat for the home, ushering in a new era of smart products that are usable to more than just (men) “geeks”. Noteworthy mention is that Philips Hue released their smart home lights the same year (Wikipedia contributors, 2021). At this point the market penetration of smart homes in Europe was less than 2% ("The Raconteur", 2022) but further aiding adoption was the release of smart home voice control systems like Amazon Alexa in 2014 (Lacoma, 2021).

With a steady increase of smart homes, 2017 saw a market penetration of 12% ("IoT Business News", 2022), the same year Sonos released their first voice controllable wireless speaker (Wikipedia contributors, 2022b). At this point, the future smart home market looked bright, estimates forecasting a growth to 43% market penetration in 2022 ("IoT Business News", 2022). Almost half-ways towards this projection, the market penetration had only reached 17% (Marton, 2021). With adoption rates having slowed down – contrary to predictions – it seems reasonable to believe that the initiated collaboration between Apple, Google, Amazon, and other big players in 2019 to make smart homes more integrated, was an act to fight this trend (Wikipedia contributors, 2022).

Now, in 2022, only 33% of European households have adopted smart products and technology ("Statista", 2022b). Multiple delays of the much anticipated Matter protocol by the aforementioned big industry players still haven’t saved our smart homes from being too complicated or confusing (Tuohy, 2021).

1.4.2 Quest for the simple smart home

Although Matter's integrating protocol is still not released, there has been ways to decomplicate the smart home experience by investing in so called 'hubs' that integrate all smart home products, to be controlled from one single app (Tuohy, 2021). One example is dutch company Homey that have provided this kind of user experience since as early as 2014. With the increase of smart home automation (Batson, 2020), users can - if the system setup is appropriately simple enough - minimise the need for a lot of mundane smart home interactions. Still, for more activity-based tasks like putting on music when cooking or dimming the lights for a more cozy vibe at dinner, users must manually control the smart home - generally by an app, or more recently, voice control.

Even though apps have gotten better, it is not always very intuitive or efficient. Enter the saviour - voice control. While cooking it is great to not have to use your sticky fingers to foul the phone but in many cases, voice control does not work - at least not for women. Numbers from 2019 show how Google's speech recognition is 13% less accurate for women; voice control accuracy for women and men at 79% and 92%, respectively (race bias makes this numbers fall even further - mixed race woman at 69%) ("Voice Recognition Still Has Significant Race and Gender Biases", 2019).

For the majority of current smart home users, voice control is a cool feature that certainly can be useful sometimes, but with its mentioned issues and users concerns for privacy have seen a trend to remove the possibilities for 'big brother' to record what we are saying. 66% of users who do not own smart speakers say they do not want them due to privacy concerns (Wardini, 2022). The brief existence of the Logitech smart home remote 'Harmony Express', meant to be heavily controlled by voice commands, speak of (pun intended) a lacking trust and adoption of voice controlled devices. Adding to this trend Swedish company Flic recently announced their smart home remote that allows for the whole family to "control your smart home devices with simple interactions, without voice controls, apps, or explanations." Their product Flic Twist has reached critical success on Kickstarter and is to be released in summer 2022. The marketing of Flic clearly shows an attempt to address the inherent failures of a male dominated industry ("Coroflot", 2022) to make the smart home experience easy to use for everyone. By developing products and services for smart homes that are inclusive and more easy to use, adoption rates could increase - going from a niche market developed for tech-savvy, nerdy boys and men (Strengers, 2015) - to become adopted by the majority of homes.

Given its goal, the Matter protocol will increase smart home adoption as it provides a better framework for developers to create products and services that work more seamlessly together. But, with the markets current gender-bias and focus on controlling it all through apps, it does not seem likely to hit the projection of 36% being deemed 'smart' in 2026 ("Statista", 2022c). That is why it is not surprising that most smart home products are bought and used by men (Zaman, 2021). As the world is almost exactly comprised of 50% men and 50% women (Ritchie, 2019), many living in homes that are perfectly suitable for adopting

smart technology, it is not hard to imagine that the male dominated industry missed a lot of opportunities for revenue - especially when statistics say women have the strongest influence on investments regarding the home (Spradlin, 2021).

1.4.3 The future of smart homes

With issues of inequality being more prevalent in media, society and politics (Horowitz and Fetterolf, 2020), there is a slow development to make products, services and legislation be more inclusive to bridge the gender gap. With the presented facts one can assume that in order for the smart home market to prosper, it needs to fully include women by designing products and services that more thoroughly take their needs in consideration. In addition, research have shown that excessive smartphone use impacts both mental and physical health - especially for young women as norms and heavy social media have increased cases of mental distress (Abi-Jaoude et al., 2020). Furthermore, research says that one interaction with the smartphone sets off a chain reaction of further use (MacKay, 2020); something that puts us in a potential endless loop of smartphone use as most smart products are controlled by apps.

This understanding that we need to reduce our screen time to remove distractions of social media and outside influence - also telling by the widespread dissatisfaction with touch panel interfaces in modern cars - have given rise to a need for interfaces that better aid our interaction goals (Prestrich, 2021). By developing interfaces that are tangible, users can be more efficient in achieving various tasks as the sense of touch guides our actions. These kinds of interfaces reduces or reliance on smartphones, making it possible to develop devices for smart home control to be without distractions. This requires designers to rethink how desired tasks can be achieved in a way that is still usable - even though the nature of tangible devices are more limiting when compared to a dynamic touch display. This quest to achieve equal, or even better, efficiency, effectiveness, and satisfaction is driven by proper care for usability and simplicity. Actually, services or products that are deemed to provide truly simple experiences fair better on stock markets across the world - one factor that unites loved brands like Netflix, Apple and Google (Clinehens, 2020).

Another important trend is the 'Right to disconnect' movement. Right now, a growing number of countries ban out-of-hours calls and emails from the boss; EU currently working on legislation to support widespread adoption, hinting at humanities need to reduce our dependancy on smartphones. Although we have spent a lot of time working from home, when more and more people are returning to work, their time spent at home will generally be in the mornings and evenings - the time that fewer and fewer of us will need to have our phones close to respond to demands from our bosses. Combine this with the universal want to reduce our screen time. And, as most smart home companies blindly continue to develop app-based and privacy-infringing voice interactions, there is a huge potential need for a way to control the smart home that is tangible and voice-control free.

Albeit having taken a noble and important step for adoption and inclusiveness of smart homes, the Flic Twist device have the risk of still being subject to the ghost of the 'white-male-default' approach of designing interactions for nerdy guys. The team image (figure 0) on their Kickstarter campaign page speaks of an even more male dominated development team than the already low number of 19% of the design industry being women ("Coroflot", 2022). Of course, any team constellation can ask the right questions and develop products for others than themselves but an analysis of what the Flic Twist offers, their promise to be simple and intuitive - "easy to use for anyone" - the product is stripped of any type of clear feedback or instructions on how to use it more than letting users know you can click and rotate the knob ("Flic Twist: The Wireless Dial for your Smart Home", 2022). This naturally contradicts the notion that it is easy to use for anyone. How do new users - or the non-tech-savvy members of families - intuitively be able to use it without fear of doing wrong?

Figure 0. The mostly male Flic team (Flic Twist: The Wireless Dial for your Smart Home, 2022).

In the coming years when all smart home products will be able to talk to each over the ether, there will be a need for one device to control all of those products - one that is not a smartphone. For such a product to take the place of smartphones as an appropriate and desirable option, a tangible device needs to be easier, quicker, and more delightful to use for both new and experienced users of any gender.

2.

Method

This chapter describes the special development process combining multiple development frameworks, and relevant methods used for each stage of the project.

2.1 Process

To leave the realm of technology-based smart home innovation, the Emotional design methodology of Don Norman was used (Norman, 2003), his method supporting design for the reflective, behavioural, and visceral level to provide delightful products (figure 1). The principle of Emotional design is to support development of products that are better appreciated by users that in turn can provide for a longer lifespan and thus less environmental impact.

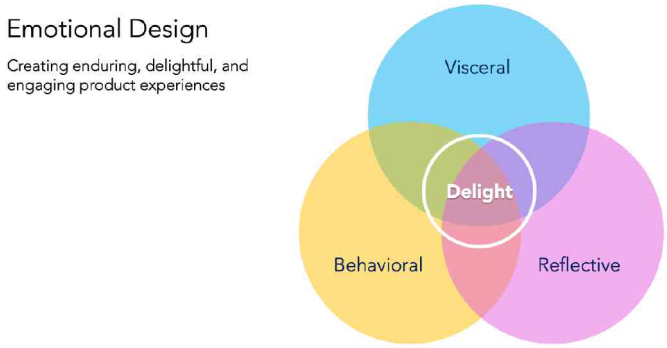


Figure 1. Emotional design framework (Baker, 2021).

Starting off with the reflective level, a guiding vision was created by help of Dutch designers Hekkert and van Dijk's (2016) framework Vision in Product Design (ViP). As the Emotional design method is not very descriptive in what to do, the ACD³, Activity-Centred Design was also used (Bligård, n.d.) – the 3 symbolising its dimensions of design grades, perspectives, and activities. Its more descriptive framework supports an evolution of requirements in line with innovation, encompassing all levels of product design from idea to production. The ACD³ framework was loosely adopted throughout the project, mainly making use of suggested tasks from the Effect, Use, Architecture, and Interaction stages.

During the initial reflective level, the smart home context was investigated to shape the project vision and exploration of what women require from smart home interaction. The behavioural level explored what users do and how they do it to aid in development of the tangible interaction concept. The visceral level, pertaining more to the appreciation of a product and the interaction with it, provided for a creative and open way of exploring how the intended concept could be materialised into a delightful prototype (figure 2). The reflective level used one set of users as remote participants in Sweden while the tangible tests of the behavioural and visceral level used another set of users based in Amsterdam.

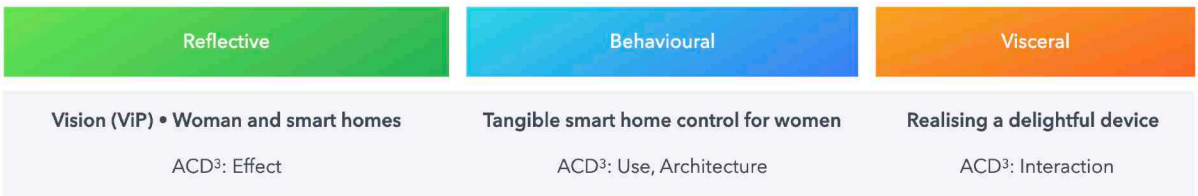


Figure 2. Project process.

2.2 Reflective level methods

A guiding vision was created, followed by a gathering of insights about the context and users, leading to a set of concrete needs and requirements for what women prefer from a tangible smart home interface.

2.2.1 Vision in Product design (ViP) method

Hekkert et al. (2016) ushers designers open their eyes to the world around them, asking them to experience and interpret product interactions and qualities around us in the selected context. By doing so the designer gets a better understanding of what is appreciated in certain products or systems, resulting in a collection of relevant factors that help shape an understanding of the context. This vision, founded in the gathered insights, help designers push for what is appropriate to initiate positive change to make products that are better suited for humans or the environment. The authors of the ViP method also proclaim that by use of their method the designer has freedom from restrictions, meaning they move in their own direction, and, thus to design with authenticity as no designer is objective and can instead use their experiences as a strength. Naturally, this also calls for the designer to take responsibility of their actions by having well-founded arguments and accepting consequences of any decisions made.

Following the ViP process closely, the background and domain of the vision was based on the results of a survey done as part of a course at TU Delft in autumn 2021 while exploring the home context, its technologies, and how inhabitants interact and feel in control of it (Appendix 1: Learnings from culture survey). This culture survey consisting of 17 questions related to smart homes was spread to friends and family on Facebook. The survey was for anyone using smart home products, wanting to have them, or living in a household where a partner or other person mostly uses such products. Many of the survey questions explored inclusivity and app-free interaction as it was found in an early article by Strengers (2015) during the course at TU Delft. 15 women and 18 men partook, their respective answers further indicating that both groups have different requirements. The survey results shaped the exploration of relevant topics on Google for this projects vision - primarily finding news articles from recent five years, and some research papers. The 56 factors found were then clustered, guiding my creation of a statement shaped by my experiences and beliefs. Next I used this statement to brainstorm suitable interaction and product qualities to be explicit, easily understandable to users, and to be original by comparing it with current smart home interfaces. With a suitable set of qualities deemed novel enough, a longer vision text was written to describe an appropriate smart home interaction scenario according to my experience, statement, qualities, and found factors.

2.2.2 Effect methods

The effect phase relied heavily on the findings and direction of the project ViP to guide the explorative work of understanding women's needs for smart home control. By following the

ACD³ perspectives of the Effect stage, performing a survey, diary study, and interviews, qualitative data was gathered from women. Quantitative data in support of these findings was then found in news articles and research papers by searching for statistics on smart and non-smart home activities and how they are split between women and men.

Online survey

An online survey of 18 questions was created to understand the smart home context, who the users are, their placements of phones, and what smart home interfaces they usually interact with. To find participants a convenience sampling was done by finding users in Facebook groups. The survey was created with Google Forms with an introduction informing the participants that if they fill and send in the form they give consent for storing their data for the duration of the project. One of the possibilities when having a strong vision by use of ViP, is that it can attract the target group - if it exists. To do this, the online form was shared with a few prerequisites based on the vision. Wanting to reach out with a smart home survey to a sample of the general population in a developed country like the Netherlands or Sweden, clusters of possible participants were reached by spreading the project statement in the Facebook groups 'Svenskar i Amsterdam' and 'Expats in Amsterdam'. Even though the participants in these groups have some commonalities, it was deemed that each group contains many different types of people - hence, a random sample of the population. To gain more users for the survey, the authors own personal Facebook was used, with friends and family sharing the post. 22 women partook, the results and demographics of the participants used as a foundation for shaping the target group to support future work (Appendix 2: Survey results).

Diary study

A diary study was performed with a selection from the target group, some of which had participated in the survey while some where friends who had smart products and an appreciation for the vision. The goal was to get some current use data, and some subjective ideas and reflections to help guide the process. After handing over a guide about the study, its goals, and how it is done, the participants started to record their daily smart home interactions in an excel-template (Appendix 3: Diary study guide). After a few days of recording their activities, the participants sent their data to the me for analysis. Data on when and where activities was performed to create an understanding of use patterns at home by visualising usage times on a graph of the daily hours while data on temporal use was illustrated as pie charts describing what activities where done where and when in the day.

Interview with diary participants

After synthesising the diary results, a semi-structured interview was conducted to gather more in-depth and qualitative data to better understand how smart homes are used by women right now, their pain points, and possibilities for improvements. The interaction and product qualities of the project ViP were also introduced as a benchmark. Some existing

product solutions were shown for participants to tell of which features they did, or did not appreciate (Appendix 4: Diary study interview).

User needs and use cases

The results of the survey, diary, and interviews shaped some user needs; concretised in a division of sub-groups as theorised by Walter and Spool (2011): functional, reliable, usable, and pleasurable requirements. The insights were then used to map use cases by illustrating what a device needs in a diagram as suggested by the ACD³ method – the Functionality perspective of the Effect grade. The diagram showing main and sub-abilities needed to support the values of the target group. Still sticking to the ACD³ structure, the Activity perspective highlights which main types of smart home products need to be controlled for a device to be desirable. In the Realisation perspective, market and user appropriateness was addressed. Lastly, all deliverables and insights for each perspective were synthesised so that an easy to grasp summary of the Effect stage could be created to aid coming development tasks.

2.3 Behavioural level methods

The behavioural level used methods for mapping tasks and affordances to aid in the development of a first digital prototype of a smart home interface for control of lights, audio, and smart TVs; then being used for testing with users.

2.3.1 Use methods

First, a modified version of Vygotsky's mediation triangle was used to clarify the relation between the tasks, users, and interfaces within the smart home context (Boy, 1995). Following the ACD³ Structure perspective, mapping of the human-machine system (Wikipedia contributors, 2022a) in a smart home was performed, based on diary and interview data.

By exploring common smart home apps, typical tasks where mapped to aid in selection of what tasks users usually try to achieve. The insights was used to structure a diagram listing main and sub-functions smartphones and smart home remotes usually provide for. Next, the following metrics for benchmarking user tests was selected: the common System Usability Scale (SUS) ("Usability.gov", n.d.), and the usability constituents efficiency and effectiveness ("What Is Usability?", n.d.). The task mapping also shed some light into what kind of interactions users do, categorising these for evaluating which types of interface components users relate to. All diary participants got a Google Form link to easily respond to this

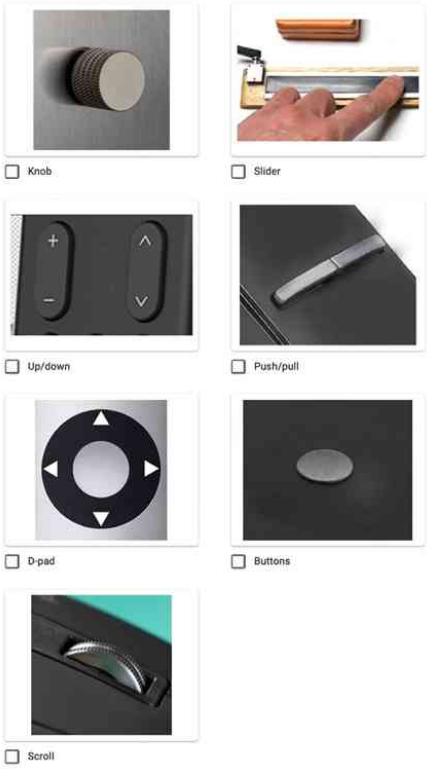


Figure 3. Affordance survey.

evaluation of affordances but only three responded to the request. Images of typical interface components were paired with questions of which they would choose for achieving different tasks like adjusting lights, volume, navigation, and to toggle items on or off (figure 3).

The results were used in a morphological matrix ("Medium", 2018), to allow for various concept combinations to be brainstormed, then sketched in dozens of variations before selecting three concepts. The results where then used to create three simple varying concepts, also evaluated by a few users by sending sketches on Facebook Messenger. Selecting a concept to move forward with, wire-framing was used to make initial layouts for each system type: lights, audio, TV, automation. The wireframes were built in Adobe XD with minimal focus on typography and colors to allow for the flow of user interaction to be explored first. Before sending out my design to experts, a self-evaluation was done by checking the design against Nielsen's 10 usability heuristics, and an affordance checklist ("Heurio", n.d.; Cho and Choi, 2020). The affordance checklist by Cho and Choi was based on research about smart home interfaces and provided some extra requirements suitable for the device concept. To evaluate the usability of my interface design, four experts got to fill out a template for an heuristic evaluation (Lin, 2021). One senior UI/UX designer woman working at a famous car manufacturer; one doctoral student in user-centred product design man; and two Industrial Design Engineering master students with UI/UX design experience - all found through the culture survey of 2021. 'Expert' here referring to people with higher education credits relating to usability and with experience from working on usability-cases or projects. The method meant for systematically checking a design towards Nielsen's 10 usability heuristics, rating any issues on a scale of severity from 0-4, 0 being no issues. All participants tested the interface on a smartphone to mimic a remote.

2.3.2 Architecture methods

The digital prototypes where refined in accordance with the heuristic evaluation insights in Adobe XD. Self-validation of the user interface was performed by using a cognitive walkthrough template, used to evaluate how users might interpret each step of the given tasks for TV, audio and light control (Dalrymple, 2019). As a lone developer, a document was setup to aid in the planning and completion of the tests (Appendix 5: Planning of multi-testing). The tests were performed at the home location of four users of the target group, three of which already owned smart products. The digital-hybrid prototype tested on an iPhone mini by use of the service Useberry, followed by a semi-structured interview on the topic of usability, physical ergonomics, and user preferences for holding and interacting with the device. The digital-hybrid prototype used a cover that would limit the users interactions to only some sections of the touch display to better mimic a tangible device. A 3D model of the cover, and the various button shapes to be tested, was developed in Fusion 360 and 3D-printed on an FDM printer. A semantic differential scale was also used to probe users on product qualities. Multiple mockups, the digital-hybrid prototype, and existing smart home remotes were used to spark conversation. A pilot test was performed with a woman at

Pilotfish; the feedback of her testing also helpful for the development of the concept. All tasks were performed in a consecutive order to evaluate how users dealt with going back or switching between systems.

2.4 Visceral level methods

To evaluate tactility and learn more about how tactile buttons work and feel, a few sets of different smaller sized buttons for prototyping were purchased and evaluated by myself. In addition, two different types of keypads were also tested. By evaluating deflection, activation force, auditory and tactile feedback, the buttons could be rated.

Making use of tutorials and information online, a set of Arduino components was purchased and soldered together to provide for a tangible prototype with enough functionality to control Philips Hue lights with relevant feedback in the device of the current brightness and color value of the light. Using resin and FDM printers, various plastic parts could be produced to enclose the prototype for better aesthetics and feel in use. Before deciding on what general shape the product and prototype should have, clay modelling provided a tactile and creative way of exploring variations in shape and how it affected the gestalt. Using a white clay best fit women's wish for a bright product. To represent the concept, renderings was created in Keyshot with photos taken of the functional prototype to further describe how the concept can look.

As a final test, the three previous participants of the digital-hybrid prototype test who already owned smart home products got to test the remote to change brightness and lights on two Philips Hue lights. Having clicked and rotated on the device, the users were asked more general questions of what they felt about interacting with the device, followed by more direct questions about how well the concept matched the vision, and if it still was appreciated by them. The semantic differential scale used during the digital-hybrid testing was reused again so the final concept test could be compared with the previous test of the digital-hybrid prototype (including the result from the pilot study with the Pilotfish employee). The semantic scale ranging from 1-5 for its polar word pairings, each score calculated accordingly: 1 = 2 points, 2 = 1 point, 3 = 0 (neutral), 4 = -1 point, and 5 = -2 points. Lastly, users were asked three yes or no questions about if they think the concept will be quick, easy, and delightful if used by them in the future (Appendix 15: Questions final user test).

Lastly, as Dieter Rams classic guidelines for 'good design' has long been used to aid developers in making good products ("Heurio", n.d.-a), it is fitting for benchmarking the developed concept as part of the concluding chapter of this report. Although it is still valid in many cases, an update was highly overdue, leading industrial designer and CEO of Morrama, Jo Barnard to update it for the 21st century to take a more existential approach of asking not only what we *can* do, but what we *should* do as designers (Barnard, 2022). This updated guideline was used as a benchmark in the end of the project, aiding selection of appropriate work for future developments.

3.

Reflective level

Exploring the meaning and interactions with the smart home

This chapter presents the project vision, current smart home market problems, and how women users interact and appreciate their smart home environment - shaping requirements for developing the inclusive and tangible concept.

3.1 Project vision

56 factors related to smart homes are summarised and described further in the next section. Below, a guiding statement, interaction and product qualities, all summarised in a concept vision. For the whole ViP, including its background, factors and clusters, refer to Appendix 6: ViP - Smart home device.

3.1.1 Statement and concept qualities

Interacting with a smart home should be easy, quick, and delightful; just like the experience of actual smart products are (figure 4).

The interaction with the product should be characterised by 'simplicity', 'delight', 'confidence', 'serenity', and 'companionship'.

The product should be 'quick', 'self-explanatory', 'enjoyable', 'familiar', 'tactile', 'dynamic', and 'trustworthy'.

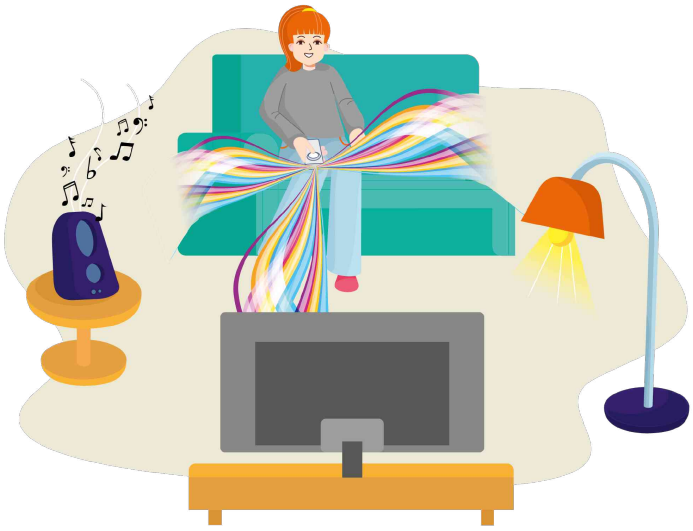


Figure 4. Illustration of how the interaction experience with smart home systems should be like.

3.1.2 Product vision

'Sally: Your Smart Home Ally' makes it easy for new or experienced users to control all smart home systems at the tips of their fingers. Its simplicity, familiarity and self-explanatory nature brings confidence to users, creating a bond of trust between the smart home and its inhabitants.

Instead of dreading tedious and distracting smartphone use, the tactile remote makes controlling the smart home quick and enjoyable; the pleasant feel of every interaction enhancing the users experience of the smart home. Its convenient size making it easy to use with one hand.

Designing for women - who are often overlooked - is not only ethical but can bring a much needed fresh perspective to benefit all users; revitalising the smart home market to increase its adoption rate, equality, and usability. This way, smart homes can finally work in better symbiosis with inhabitants to provide a serene and delightful experience worth longing to.

One device for anyone to control the smart home in an easy, quick, and delightful way.

3.2 The smart home and its users

Looking at the reflective level of Normans Emotional design framework, it is about long-term product relationships; our feelings and satisfaction from owning, displaying and using it. To increase the personal satisfaction of using any product system - in this case a 'smart home' - the user must feel that it matches their long-term needs and goals. The other two levels, behavioural and visceral, deal with the 'now', your feelings and experiences in the moment when interacting with a product, both of which will be approached in consecutive chapters. This chapter explores and clarifies who the users are, their smart home context, what smart home goals they have, and most importantly, how they want to achieve them in a meaningful way (Norman, 2003).

3.2.1 Relevant research questions

- What do women, conscious about their smartphone use, require from a tangible device to make it a preferred option for achieving common smart home tasks?
- What smart home systems are commonly controlled, how, and when?

3.2.2 Tasks and problems of the smart home domain

To clarify home tasks distinctions, users speak of chores and pleasurable activities; the former being repetitive and unwanted, something that potentially could be automated in a smart home. The latter on the other hand, is more about pleasant rituals like cooking, watching TV, or perhaps having dinner with friends (Coskun et al., 2018). The difference between home tasks can be described as proximal and distal, the former being related more to current goals and activities, the latter more towards tasks we plan for and often try to simplify to minimise the burden of chores at home. The proximal tasks better align with a meaningful human-product relationships at home as “the point of technology is not to replace experiences that we already enjoy today with our families ... (but to) support or enhance experiences you already enjoy ... but in new ways”. (Heath and Bell, 2006). As presented in the introduction, research and statistics have shown that current smart home products lack the functionality, reliability, and usability to provide us with a pleasurable interaction with the smart home - whether it is for distal tasks of automating the smart home, or proximal tasks for current user goals and moods.

The extensive gathering of factors relating to the domain of 'smart home control' painted a clear but multifaceted picture of what is hindering smart homes from becoming widely adopted at a macro level. The main insights of each cluster presented on the next page.

Smart home adoption is slow due to misguided efforts

- Smart home market adoption rate has slowed down, now only at 33% market penetration now, compared to the projection of 43%.
- Smart homes have been designed by and for tech-savvy men, leading to the market being stuck with early adopters as their main user group.

Interacting with smart homes is complex

- Current smart home use lacks proper integration between systems, leading to a more daunting and demanding interaction for new and experienced users.
- The much-delayed smart home protocol Matter aims to integrate all systems for a more seamless experience.
- Dutch company Homey already provides an integrated solution, albeit only usable with smartphones, tablets, or computers.
- Activity-based interaction tasks are not easily automated as they are based on users current, and often changing goals.

The right to disconnect: Reducing screen time for well-being

- Excessive smartphone use is a health hazard.
- Majority of people feel a need to reduce their screen time.
- Increasing number of countries legislate to ban out-of-hours calls and emails from work.

3.2.3 Smart home survey and demographics

22 women who had an appreciation for the vision statement and concept description joined the survey; collecting data on their smart home use, products, interactions, and general demography. Using the vision as an attempt to attract a target group, the demographics of the participants materialised as mainly millennials (born 81-96) and a large chunk of generation X (born 65-80), the majority living with a partner or family in 50-100 sqm apartments of generally 2-3 rooms. Participants living arrangements split equally in thirds; alone, with a partner, or in a family or similar. Those who live with others mainly having shared control of the smart home.

Most women said they are a big deciding factor for what smart home products to buy; almost half decide mainly on their own while others decide in agreement with a partner or family. The product categories owned by the majority were smart TVs, smart lights, and smart speakers. Some also had smart assistants but very few had products like security systems, sensors, or thermostats.

Majority of users deemed themselves as competent in controlling their smart home, most often done through smartphone apps. A tangible remote was also an option for half of participants; often for quickly controlling smart lights. Some automated their smart home and some used voice control. Very few relied on sensors. Amount of smart home products varied but even when only having a few, a remote was often used as a complement to the smartphone. Lastly, the majority of participants mentioned concerns of excessive smartphone use, reasons varying: 'reducing time in general', 'reducing time in evenings', and 'not wanting the phone in the bedroom over night'. Based on the survey result, the following key indicators were selected as important to describe the target audience (Appendix 2: Survey results).

- Age range: 25-64 years (Millennials and Generation X).
- Gender: 100% women (not rendering any future solution unusable for other genders).
- Buying decision power: Strong (at least equal with potential partner).
- Living setup: Mid to large apartments with 2-3+ rooms.
- Living arrangement: Majority living with others (partner or family).
- Main smart products: TV, lights, speakers.
- Smart home control: Most often on smartphones, less often on tangible devices.
- Majority want to reduce their smartphone use.

3.2.4 Smart diary and interviews

The diary participants were of age 18 to 64 - four 'millennials' and one 'Generation X' - most living with a partner or family in 2 to 3 room apartments of approximately 75 sqm size (table 1). All of them owned smart smart speakers, lights and TVs with interactions split among their phones and tangible remotes; the latter two mostly controlled with remotes. One difference between the target audience and diary participants was the latter groups all-encompassing use of smart lights. A synthesis of the diary input and the results the sequent interviews follow below (Appendix 7: Results of follow-up interviews).

Table 1. Participants of the diary study.

	Age range	Smart home experience	Living arrangement	Living size (all apartments)
User 1	18-24y	Competent	w. partner + cat	3 room, 0-50 sqm
User 2	55-64y	Competent	w. family	3 room, 50-100 sqm
User 3	35-44y	Competent	w. partner + infant	3 room, 50-100 sqm
User 4	25-34y	Novice	alone	2 room, 0-50 sqm
User 5	25-34y	Competent	w. partner	2 room, 50-100 sqm

Discussing the meaning and utility of smart homes, it was clear that all users wanted convenience to make it easier to control the house, but also to gain benefits like adjusting lights accordingly for different occasions when wanting to read or putting a baby to sleep for example. Usually apps are used as the main interface but often tangible remotes for light control was used as well - the later preferred for its each quickness and ease of use. Most often the participants controlled music or adjusted lights; some feeling that dimming is enough of a functionality while others wanted to adjust colors and maybe even try to automate some lights. All users did have smart TVs and watched them regularly, feeling that an integrated way to control all home devices would be appreciated - if it is quick, reliable and self-explanatory. Showing different products for controlling the home sparked discussions on pros and cons for each product; Flic Twist, Harmony Express, Sevenhugs Smart Home Remote, and the Homey app. The consensus from this was a need to have an integrated interface that is truly capable of achieving a lot, the Homey app favoured by many for its integrating abilities. At the same time when discussing issues of being connected by their phone or potential use of wearables, the majority felt that something more disconnected like a non-smartphone interface could be a viable option if it could be brought, and put on a dedicated spot like the wall or a counter when wanted. As many lived with a partner it was mentioned that they often shared the tangible light remote, but it was rarely a problem - it could move though by the partners hand, which could be frustrating when the main user did not find the remote.

Having an open discussion about the proposed interaction characteristics and product qualities from the vision helped shed some light on how the participating women interpret

each word. Generally the less abstract words like simplicity, quick and self-explanatory were highly appreciated as well as dynamic; being able to adjust to the users needs or show different things (as compared to typical 'static' remotes). On a more inter-relational level, participants deemed confidence and trustworthiness important aspects to give users a sense of accomplishment and possibility to rely on the devices performance. Companionship and familiarity was commented on by some as desirable as it would make the device more usable and quicker to learn. The more abstract words like delight, serenity and enjoyment were not sparking any real interest. One user did mention tactility as something good as it enhances the use of tangible devices to be more pleasant - still not unappreciated by the other participants as other discussions in the interviews regarded tangible devices as the most simple and quick way to control the home. Voice control and wearables as an interaction option was also discussed and disliked or not tried by most users. Discussing patterns of bringing their phone around the home, all women kept the smartphone close at hand, but not on their person. Usually the phone was brought to the room they generally spent some longer time in and had its common resting place like the living room table, kitchen counter, or night stand - depending on the user. In summary, users said they desire a way to control most things of the smart home like the smartphone apps do, but to be controlled from one device or app; supporting quick, reliable, and self-explanatory interactions.

Interaction character, frequency, and locality

Analysing the times of day when smart home tasks are mostly done, the variety in diary inputs ranging from weekdays and weekends, working from home or taking care of a child also affecting results, users interact with their smart homes over the whole day. Depending on the user, one could see two different use patters of either heavy use during the middle of the day, or, more in the morning and evening. With the relatively small sample size, these results are not a given but by analysing the specific tasks, it is reasonable to assume that these patterns match common routines like making breakfast or dinner, and enjoying some TV time or listening to podcasts.

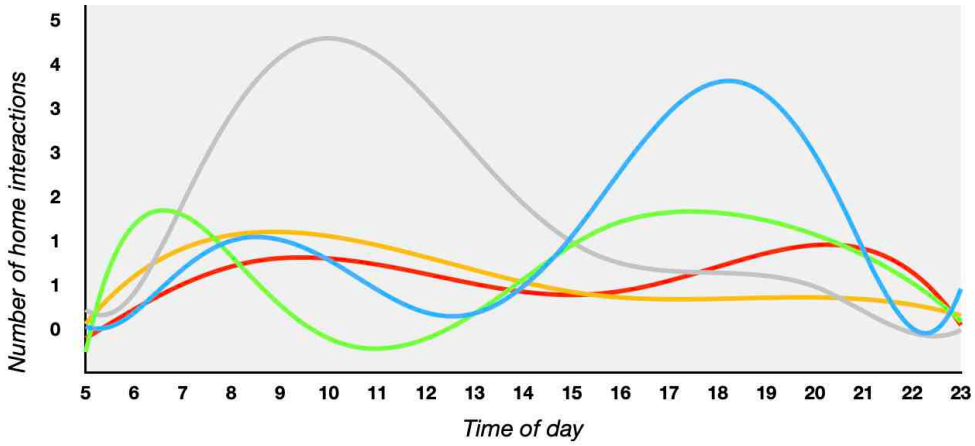


Figure 5. Time of day (horizontal axis). Number of interactions with a smart home app or remote (vertical axis).

Even though the sample size was small, and with a variety in when and how much users interact with the smart home as seen in figure 5, it is clear that the relationship between individual users, their smart technology and home is complex (Hughes et al., 2000). With that said, it is deemed reasonable to view the chain of pleasurable activities at home as something happening in one room per main activity. As examples of reference, one might want to listen to music in all rooms when achieving a chore like cleaning, but for pleasurable activities like watching TV, cooking, or having dinner, the inhabitants are generally in the same room for an extended period of time. These scenarios seem reasonable if only one person is achieving one pleasurable activity at a time. When users are living with partners or family, like most of the study participants do, there are potential issues arising from sharing a device. Some participants said that sharing a remote for light control is rarely a problem, it usually remains in one room - albeit sometimes changing exact location. For a more capable device meant to be used in all rooms of the home - for chores or pleasurable activities - it could prove harder to share. But, a British study from 2020 found that couples usually spend around four hours per day in the same room (A. Hughes, 2020) - not a specifically low time given that British people usually spend almost 3 hours on eating and watching TV (Ortiz-Ospina, 2020), also the most popular things to do together as couples. While different interests, work routines and cooking might make us spend time in separate rooms, most of the pleasurable activities for couples are spent together.

Even though smart home control becomes more complex in family households, it is still possible to decrease this complexity by use of just one smart home remote that is capable and pleasant to use. If deemed helpful enough, more remotes could be added to act as personal devices, or possibly rather as devices spread out on set locations across bigger apartments or houses. This idea of having a central spot where such a device could 'live' when not in use, was supported by the diary study as all participants wanted to bring the device in addition to having a dedicated static spot for it on the wall as some competitors do. Mapping the diary data to a wheel, illustrating a common full day and night cycle for each user, one can see how their use differs in character, frequency, and locality - as well as which devices they often use (figure 6). Seeing that all users already have some kind of secondary device like a remote for achieving smart home tasks, they explained how they already value tangible devices for their quickness and simplicity.

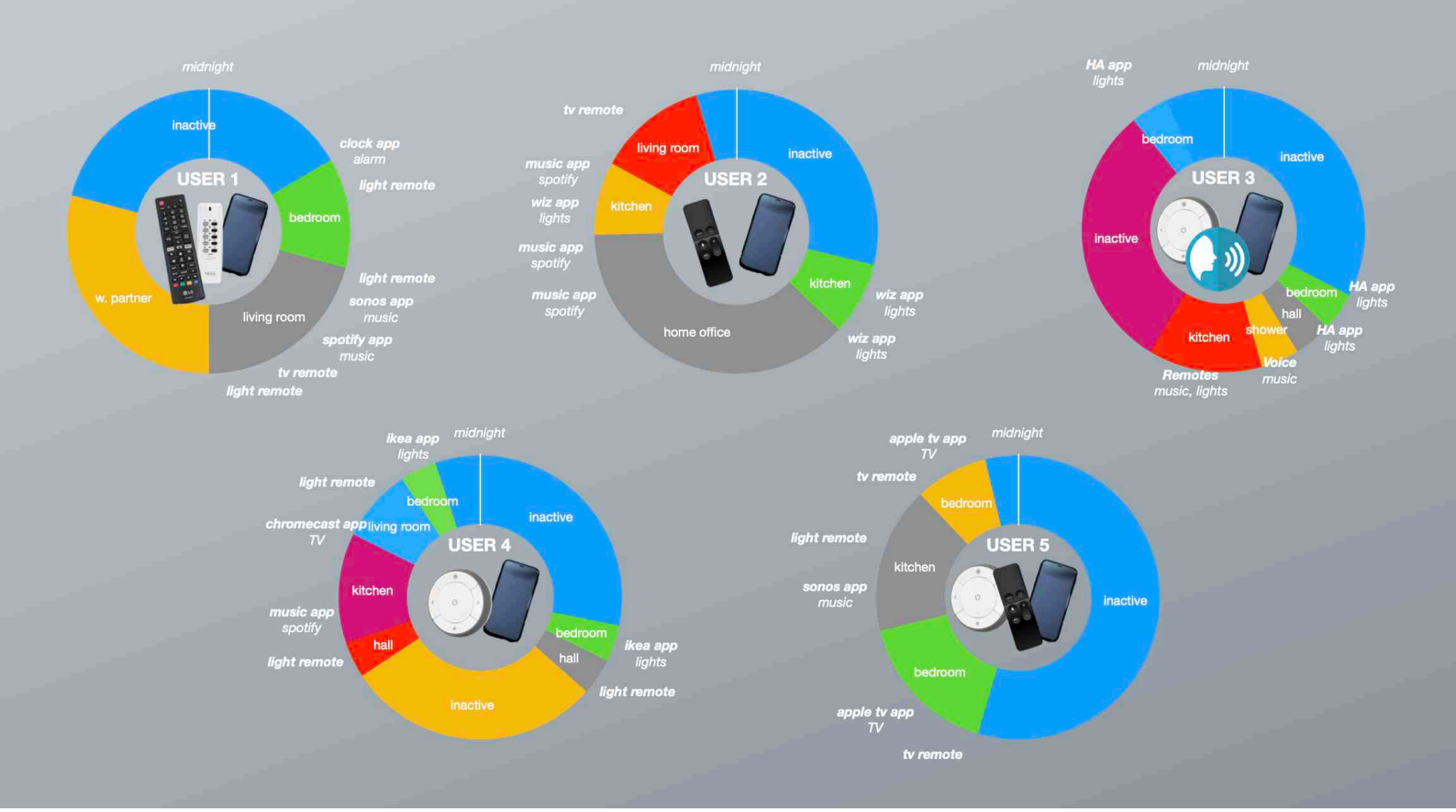


Figure 6. Typical smart home interaction day cycles.

Diary study summary

The interview results show that a capable, quick and easy device for controlling most of the smart home could improve users smart home experience - especially if it is implemented as a physical complement to an already integrated app like Homey. With their app platform, setting up a remote could be easily done, with the app used for achieving the remaining minority of more uncommon smart home tasks that the remote is not capable of.

As it is now though, the majority of users have multiple ways of controlling their smart products, mostly through an app but also with one or more complementing remotes in most cases - most often used for light control. Here is an opportunity to provide a device that could replace all or most of these extra remotes so that the user only need to rely on either the phone or the to be developed product. Surely though - simpler permanently mounted devices for light control for example - could still be a reasonable complement as well.

Given the common multitude of interaction options, an analysis of the diary results showed that users often seem to interact with the smart home through the closest device that can achieve their current goal. With the notion that all users did have different opinions on the comparison of competitor interfaces, it seems that closeness to a device trumps usability - analogous to the saying "the best camera is the one you bring with you". This means that for a tangible device to be usable as a complement to the smartphone they usually bring around with them - or even provide a scenario where the phone is kept at a distance more often - it needs to be capable enough to achieve users most common smart home tasks in a way that is easier, quicker, and more accessible than picking up the smartphone.

3.2.5 User needs for deep delight

Considering that most smart home tasks are done in the morning or evening in relation to pleasurable activities, a smart home remote should match the control needs arising from these situations, and if possible, make sure that each interaction brings some amount of delight in the adjustment of the home environment.

The interview with diary participants was used to further increase the understanding of their smart home context, but more importantly, to understand their needs in a more structured way. In Walter's book Designing for Emotion, a hierarchy of user needs makes design pleasurable only if its functional, reliable, and usable - all five levels classified as needed to achieve 'deep delight' in human-product interactions (figure 7). 'Surface delight' on the other hand is more contextual, like the beauty of an interface (Fessenden, 2017), an area that will explored with users in coming chapters.

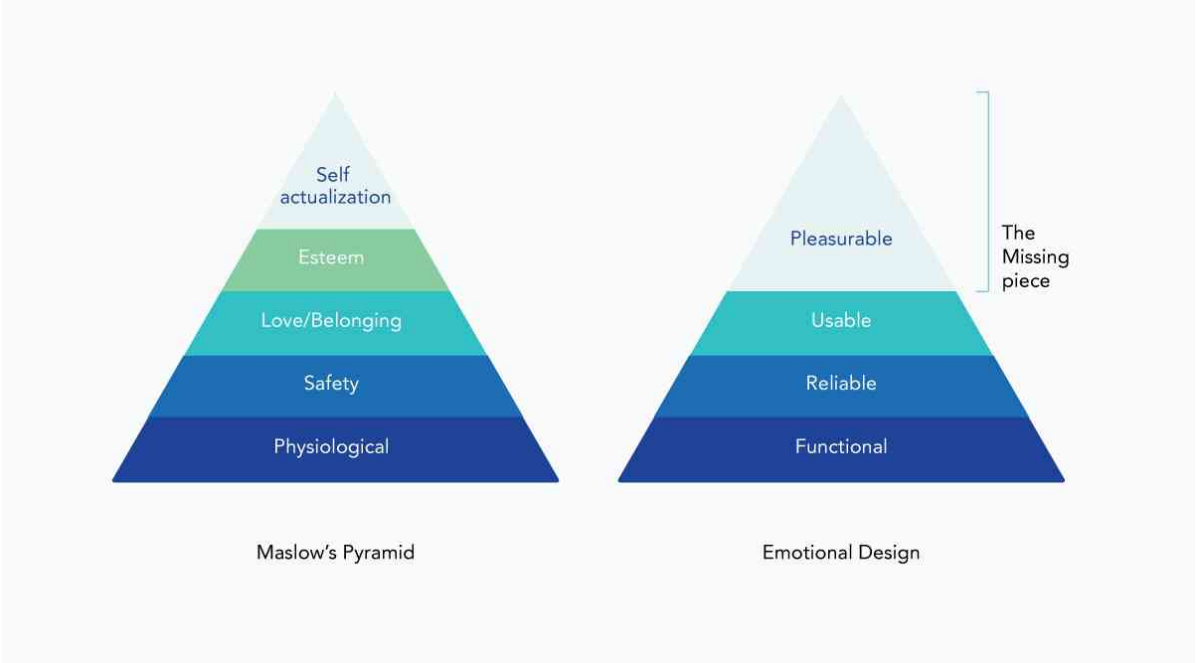


Figure 7. Walter's book Designing for Emotion describes how pleasurability only can come when a product is functional, reliable, and usable.

With the ever-growing complexity of the smart home and its interactions, the need for providing a solution that can handle the heterogeneous array of connected devices is desirable for users (Banerjee et al., 2018). In the scope of this project, to allow for single point interactions with the most common smart home systems that users deem necessary for daily or weekly tasks. Following the framework of Walter's pyramid, the semi-structured interviews was used to gather relevant insights inline with the vision, while still allowing for users to reflect; insights gathered and synthesised into 20 needs with an emphasis on functionality and usability, summarised below. For a full list of requirements, refer to Appendix 8: Needs and Requirements.

Functionality (8 needs)

Due to the heterogeneous nature of connected devices, or Internet of Things (IoT), the main abilities for a smart control device wanted by participants is for it to be user-friendly, integrated and convenient - an app deemed as an acceptable and reasonable option as most have smartphones. But, with participants emphasising quick and easy control in combination with the desire to disconnect, a tangible remote is an option that better fits with their values. The outspoken desire to adjust the smart home manually according to moods and activities make the ability for a device to control the smart home without a phone in a manual way very important. The interest in automations, if made easier to program and trigger, was also deemed important. Some more important sub-abilities is for the device to provide dynamic usage, as well as the possibility to use it whenever and wherever needed in the home. Refer to figure 8 for further details on the use case, device abilities and its connected scenarios. So you might ask, does the men don't want the same thing? Well, they probably want a lot or all of the abilities stated in figure 8, but when I have talked to men they usually reply with wanting all of this in a way that requires more buttons, longer interactions, and look less appealing. And often feel content with what they have. Like one man designer said: "Why not use the phone, then you have full freedom of the design towards the user". This might be a convenient stand-point for the designer, but not looking out for the best interest of the users.

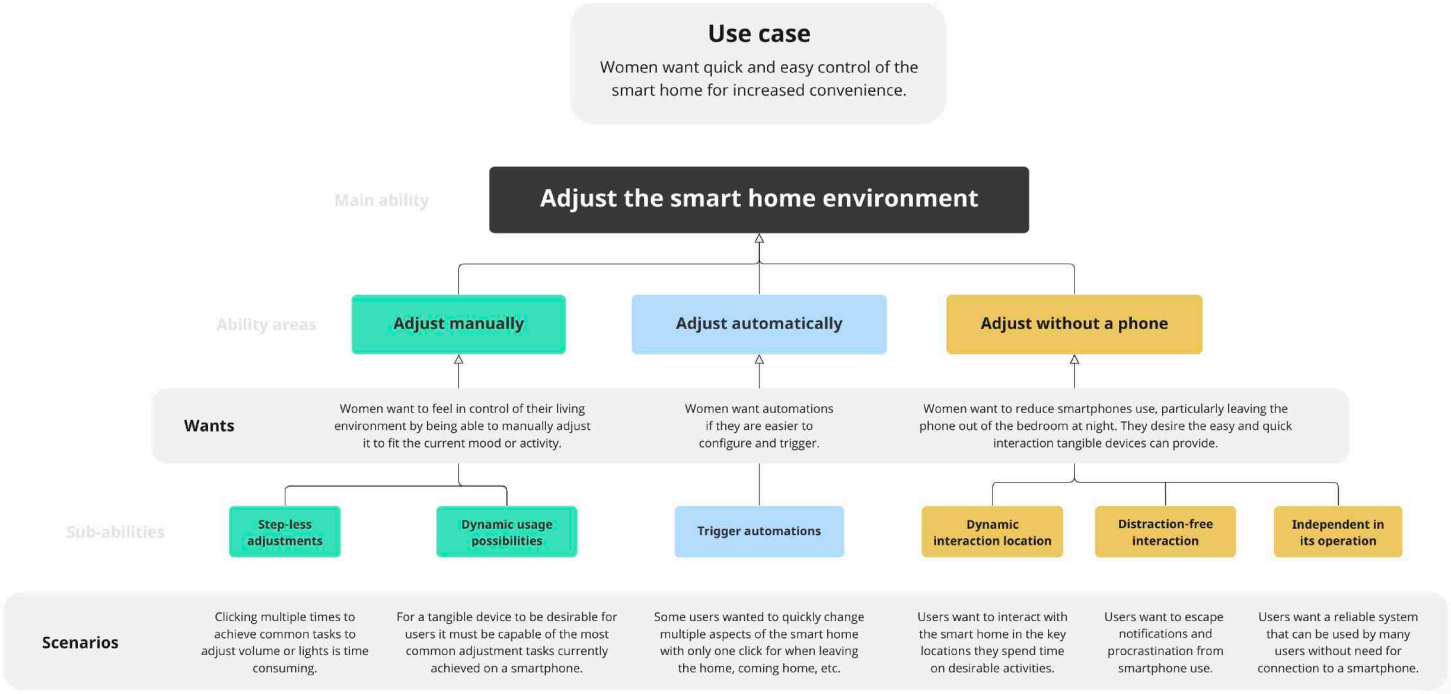


Figure 8. Use case, device abilities, and connected scenarios.

After discussing the benefits of voice control for cooking activities or snacking in the sofa when hands can be messy, structural demands of resistance to dirt and liquids need to be considered and maybe even minimise the existence of crevices to ease cleaning. For a tangible device to be usable as an alternative to voice control, users need to feel confident in the durability of the device even when interacting with dirty hands - or dropping it.

Reliability (2 needs)

In addition to the importance of exploring what the actual device functionality should be according to users, reliability was deemed as a prerequisite to make smart home use convenient. This means that a device should be quick and trustworthy, performing tasks as users expect them to be performed - every time.

Usability (7 needs)

This area of many user needs comes from users comparing the interaction experiences in their current smart homes with a possible future outlook they would appreciate. Most needs relating to issues of intuitiveness and ease of use, a device should be simple and self-explanatory with clear feedback; all helping to reduce learning curves. Supporting this are the needs for interactions to require few clicks or steps. Lastly, installation of such a device should comply to all of the above to increase the chance for user gratification towards the system.

Pleasurability (3 needs)

Being more abstract and hard to achieve, not as many needs were found at the pleasurability level but all participants valued a distraction-free interaction to provide pleasant and serene smart home control. Some participants also valued high quality materials and/or tactility as it was thought to improve interaction delight.

3.2.6 User activities to support

Even though survey and interview insights showed that many live with a partner whom they control the smart home with somewhat equally, sharing remotes for light control was not deemed as a problem by participants as these rather limited devices were often located in the same room; seldom being brought around the home. With the introduction of a highly capable device for smart home control that is to act as a complement, or even as a replacement to the smartphone as the main smart home interface, a capable device might be moved around the home more frequently. This could pose an issue but as most participants said they would bring their smartphone in most cases around the home anyway, in the situation where another inhabitant is using the tangible device, other inhabitants can easily default to their smartphones.

For the primary user, the one using the device at the moment - in this case women of households - use it for control of the smart home to adjust smart products in aid of their desirable activities. As the main modus of operandi with a tangible device will be manual, the following main areas of proximal tasks are deemed necessary to provide for to control the smart home in a holistic and convenient way that supports pleasurable activities relating to auditory and visual experiences. In addition, smart home devices that have simpler interaction needs like smart thermostats that can either toggle or adjust temperature, will also be possible to control to make the device highly capable.

- Adjusting smart lights (brightness, color and/or scene presets).
- Adjusting smart speakers (selection of played media and basic control).
- Adjusting smart TVs or similar (selection of played media and basic control).
- Control smart thermostats and other less common connected devices.

3.2.7 Appropriateness for the market and women

With the selection of activities for the device to support, it is also important to reflect upon what context such a smart home device will be part of. Both in regards to the market and possible integration with a smart home company, and how the device should be developed to be appropriate for women. The product will be developed with market and end-user circumstances in mind, mainly meaning that the product can not be too expensive or lack the critical ability to provide holistic control of the smart home. How the upcoming release of Matter, providing an integrated way of controlling the smart home from one point - whether it be an app or tangible device - will influence smart home sales is hard to predict but the insights gathered during this stage of the project shows a strong need to provide ways of decreasing our reliance on smartphones for interacting with the smart home.

Prior attempts at making smart home interaction better has generally failed; partly due to not providing interfaces with enough capability to control most of the smart home, partly due to devices being designed for men. This has created a market were voice control is not as desirable or reliable for women. Additionally, rising concerns for privacy issues in voice controlled home impacts women even more as they can suffer from smart home-enabled abuse to a larger extent ("TechCrunch", 2013). This includes using smart cameras for monitoring and harassment by controlling smart locks, speakers and lights. Although the existence of any common smart home product like smart lights can be used for harassment of women, the exclusion of gesture or voice-based interactions can eliminate much of the monitoring possibilities for abusers.

3.2.8 Summary and synthesis of ideas

With the target group emphasising manual control of the home, the users appreciated their tangible remotes for its ease of use and quickness. All in all, for a tangible device to trigger automations or provide manual control of the smart home when desired in a convenient way, it needs to be quick, self-explanatory and reliable; also capable of achieving most common smart home tasks to make it a competitive alternative to the current heavy use of smartphone apps. For a device to be capable, users primarily want control over music and lights, but also smart TVs. Even though control of smart TVs might not be revered as a typical smart system that relates to the home in the same way as smart speakers and lights do, users saw a benefit of reducing the need for different tangible devices in the home like TV remotes. As TV watching is a desirable activity it makes sense to include its control into the

device. In addition, as many smart TV devices like Google Chromecast provide smartphone apps for control - or by other home cinema remotes through HDMI connectivity - interoperability with a novel tangible device is feasible.

In addition to the exploration of which activities to provide for, and how, probing about pleasurability in the current or future interactions was not as fruitful as wanted. The users spoke of smart homes being meaningful when they are convenient by achieving smart home tasks more easily and quicker, but a deeper discussion on how these tasks could be achieved in a more delightful way was not successful. Noteworthy, even though adjusting the lights might only be utilitarian to see well during chores, for the sake of conformity, adjusting the lights is deemed to be part of the pleasurable activities as it is common to adjust lights to help us wake up easier, have a cozy time in the sofa, etc.

Looking at other than tactile interaction options, the lukewarm response to voice control in combination with users experiences, and research highlighting how it is not working as well for women as it is for men, renders it excluded from the design space. Concerns for privacy also render camera-based gesture control potentially harmful to women users. Additionally, both voice and gestures are not as appreciated as tactile interactions that often are quick and reliable, making the latter better suited to strike a balance between novelty and familiarity. Hence, this project will focus on camera and microphone-free interactions, to rather use familiar and more common interaction elements like buttons, knobs, etc. Discussions on wearables as another alternative showed that most users disliked them; either deeming such an interface too limiting or too expensive. Also being a device that they do not wanna wear on their body for its size, or for being seen as something connected, thus impeding the need to disconnect.

It is assumed that if a device feels too far away or shared by too many in a bigger household, the budget spent on the larger amount of connected devices to cover all wanted rooms make investment in multiple devices feasible as this additional cost would be the same fraction of a smaller homes smart home investment. For few devices and rooms one device might suffice, and for many devices and rooms more devices might be wanted. It is reasonable to assume that the number of control devices needed are in correlation to the amount and placement of connected devices bought for the home; a situation where more than one device might be needed is not seen as a design flaw but rather a decision for home owners to meet their convenience needs. Ultimately though, the goal is of course to develop a concept that with its combined capabilities can provide an experience that is desirable enough to make users wanna collect the remote for interactions even if it is further away than the phone. This dynamism in letting users choose where to use or store the device was appreciated by diary participants. In addition to being dynamic in its use and placement, one interesting idea from a participant was to have the device be time, place or user adaptable, meaning what functionalities are currently presented can change depending on the time of day, location in the home, or whom the current user is. This might prove to be

a good direction to make a device shareable in a more personal and effective way between multiple inhabitants. Below, relevant insights from the reflective level chapter summarised.

Main problem

- Gender bias impedes the usability for all.

Context

- Smart home adoption is slow due to misguided efforts.
- Interacting with smart homes are generally complex.
- The right to disconnect: There is a movement to reduce our screen time.

Target group

- Demographics: Millennials and Generation X (25-64 years).
- Women value: convenience, simplicity, reliability, holistic interaction.
- Challenges: smart homes are controlled by multiple devices.

Abilities and needs

- Women want quick and easy control of the smart home.
- Women want both manual and automatic control of the smart home.
- Women see a tangible device as an option if efficient and capable enough.

Activities to support

- Adjusting smart lights.
- Adjusting smart speakers.
- Adjusting smart TVs or similar.
- Controlling other heterogeneous smart home products and automations.

New delimitations

- Voice and camera-based gesture control excluded.
- Wearables as interface option excluded.

Opportunities

- A device that adapts its functionality dependent on the time of day or place at home can further improve convenience for single user homes, but, user adaptability can also benefit multi-user households.

4.

Behavioural level

Exploring the performance of smart home interfaces

What is required of the interaction design to be able to control music, lights, TVs, and other connected devices? This chapter is about the development of a usable and capable interface for heterogeneous smart home control.

4.1 Usability and references for design

With smartphones having been designed for a huge variety of tasks, these near infinite possibilities make them less perfected for the demands of context-specific activities like smart home control. On the contrary, tangible smart home remotes have generally been designed for a very limited set of tasks - but do them very well. Ultimately, if the possibilities and limitations of the smart home context is taken into account, the qualities of smartphones and tangible devices could be combined to create a more convenient and thoughtful smart home interaction for users. Current artefacts used for smart home interactions are primarily smartphones, with various remotes - often limited in its capabilities - as supporting interfaces with higher efficiency and ease of use in turn. By use of a variation of Vygotsky's mediation triangle (Boy, 1995) current inter-relational problems in smart home control can be visualised (figure 9). What general tasks users want to achieve has been answered, but what relevant sub-tasks required for that achievement are to be explored in this sub-chapter. How to achieve good cognitive ergonomics are to be explored by designing interfaces according to usability guidelines. The task-interface relationship is based on user needs and will be explored further in sub-chapter 4.2.

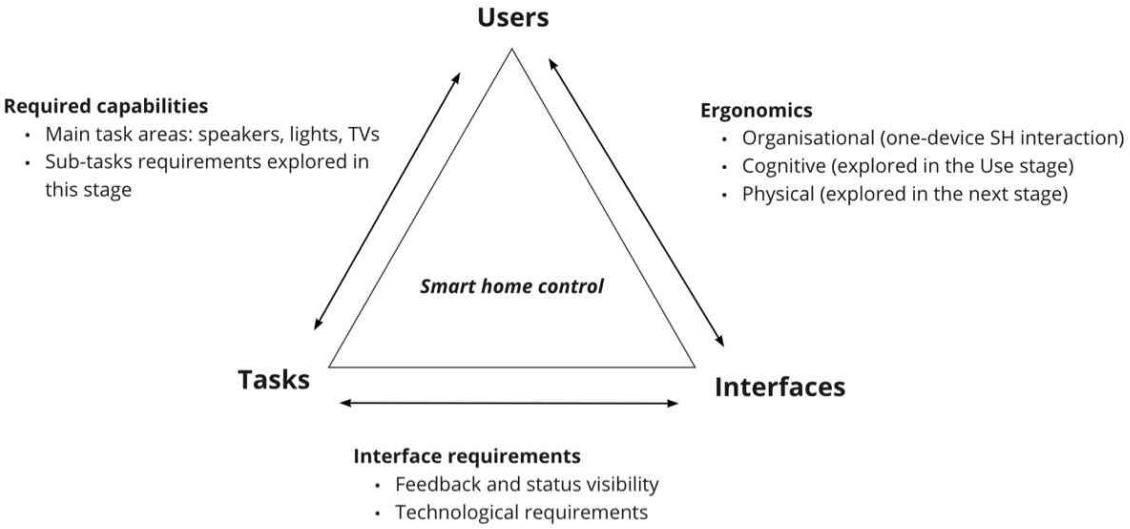


Figure 9. Users, tasks and interfaces (SH = smart home).

4.1.1 Relevant research questions

- How can a tangible device be developed to achieve common smart home tasks more efficiently and effectively than using apps? (tangible in what way)
- What systems and components of the house affect smart home control?
- How are common smart home systems currently controlled?
- What metrics are relevant for evaluating usability?
- What interface components can provide a familiar and efficient interaction for the selected smart home tasks?

4.1.2 Human-machine system of smart homes

How the smart home is adjusted and appreciated by users depends on the available types of products to control, and which interaction devices are in proximity for completing any desired task. It is also dependant on the inhabitants and their routines for what they do over the day, where their non-static devices move around, and where their smartphone is charged. While the diary showed that people tend to have different and somewhat irregular phone charging patterns, most charge it in a specific location like the hallway, kitchen, or bedroom. Depending on the time of day, the current mood or goals, users generally put their phone away for some time to charge or allow for some distraction free windows of time. As most users lived with a partner or family, there is a possibility for these inhabitants to become the main smart home user at any time depending on the dynamics of various activities in the home. Figure 10 visualises a common smart home and relevant human-machine systems and dependencies according to the target group selection.

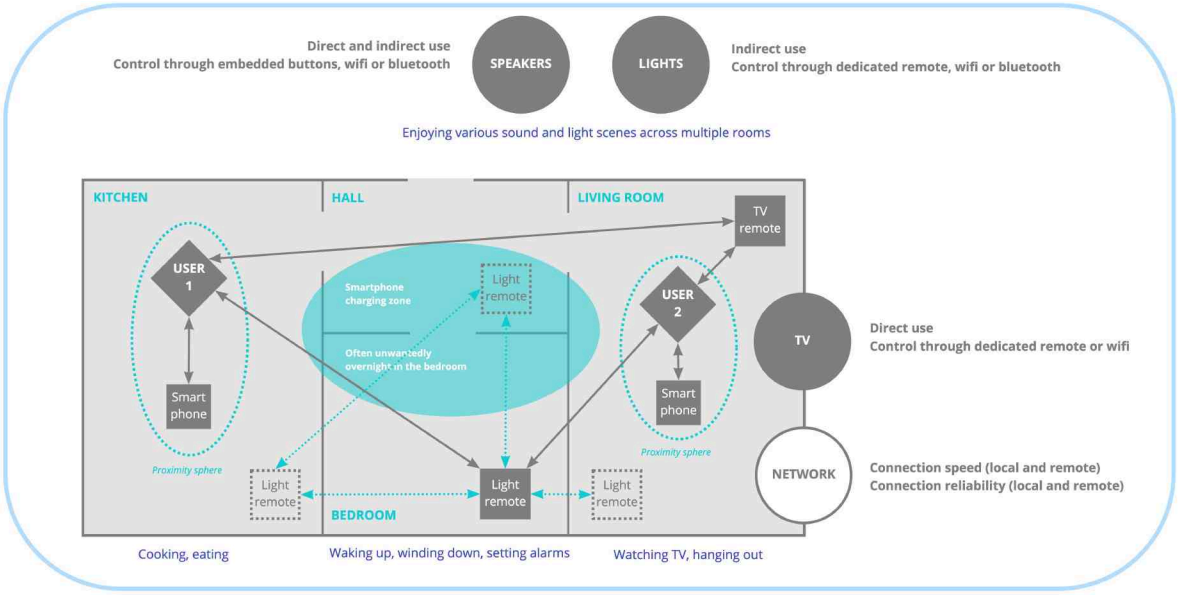


Figure 10. Human-machine system of a smart home

The smartphone is often brought in proximity with the user for other daily tasks not related to the smart home, like communicating with friends and family or checking emails for work. Interestingly though, the smartphone apps provide a very high capability for what can be controlled in the smart home but with high capabilities, high complexity usually follows, meaning that achieving certain smart home tasks with a smartphone is not always effective. No matter which smart product type is used, it can be experienced by one or multiple people at the same time, directly or indirectly, the former being when subjects are actively making use of what the product provides. For example, usage of smart TVs are a direct activity when people watch TV series or movies, while lights can be more indirect as a parameter for setting the mood in a room. Speakers provide interactions that shift more often between direct and indirect use as inhabitants attention to the sound might shift over time and space.

One important factor for all interactions to work is the speed and reliability of the local network and its connection to the internet. Some smart products rely on proximal bluetooth connections while most modern devices use WIFI for its wider range and possibilities. With most devices being connected to the home network, its performance directly impacts the interaction experience as occasions with slow or unresponsive network connections have caused users irritation and inconvenience - contrary to what the smart home should provide. Some services even require an internet connection for communication with servers to be operational - something that this concept should not be limited by. While the speed and reliability of the local and external networks cannot be affected by smartphones or remotes, requirements for such devices to maximise their performance is important to improve the overall efficiency and effectiveness of smart home interactions.

Current human-machine device division

Looking at spatial, temporal and cognitive parameters, as well as what each device is capable of, it is clear that smartphones are the most capable device by far. Even so, remotes are still used. Figure 11 shows how the smartphone, with its high capability, is the most used device, even though tangible remotes are used as well. Counting the remote used for controlling a TV, Google Chromecast or similar, most households have two tangible remotes with limited capabilities that still are used daily for its efficiency and effectiveness for the specific tasks they were designed for. These devices are less often in close proximity to the users. Still, when pleasurable activities are supported by those devices, they are approached by users and used instead of the often proximal smartphone. Clearly, the various types of devices have different benefits and drawbacks and are used differently depending on the location of the user, and their current activities at home.

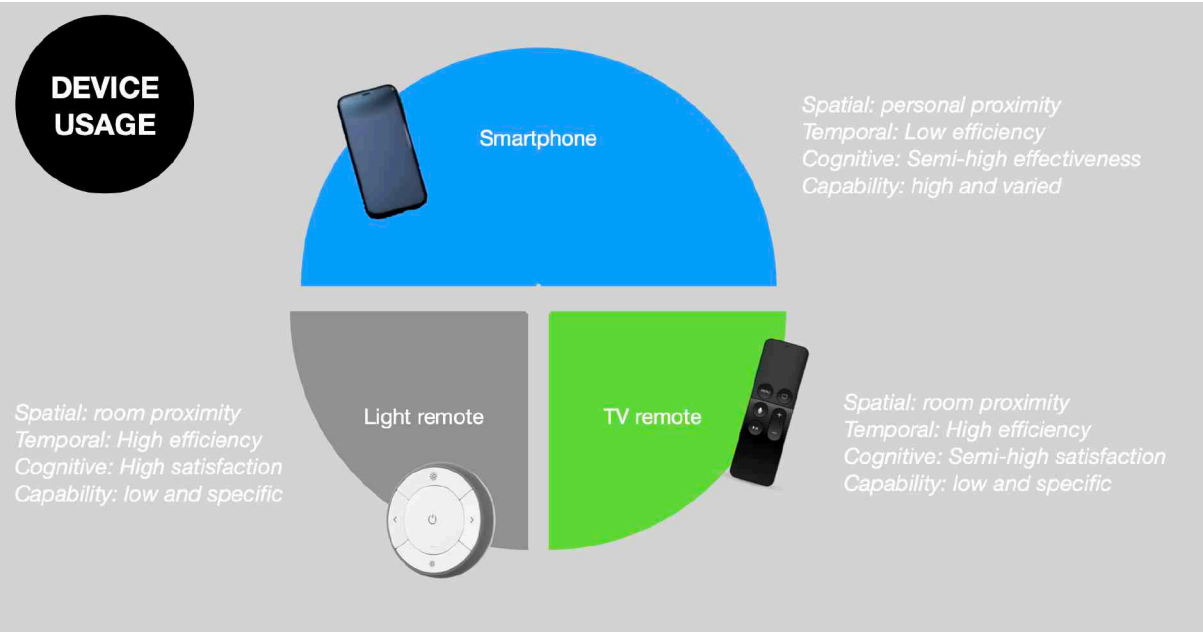


Figure 11. Device division found in the diary study.

4.1.3 Common smart home control

So what does these smartphone apps generally provide for? And what is achieved on the remotes? What users generally do with music, lights and videos will now be explored by evaluating the common smart home apps Philips Hue + Homey, Spotify + Sonos, and Netflix. Each controlling lights, audio, and video streaming respectively.

Light control: Philips Hue and Homey

The Philips Hue app lets users control brightness and color for multiple different rooms in a home. Common tasks is to either turn on a whole room and adjust its light, or control a specific light. Users can also activate so called scenes, a saved setting with specific colors and brightness for a room or area. Another option is to use the Homey app, or any other smart home assistant apps like Google or Apple Home to control the lights (figure 12). These apps are also designed to control most other connected devices in the home but given that lights is the most common smart product owned by users, it is light control they are used for primarily.

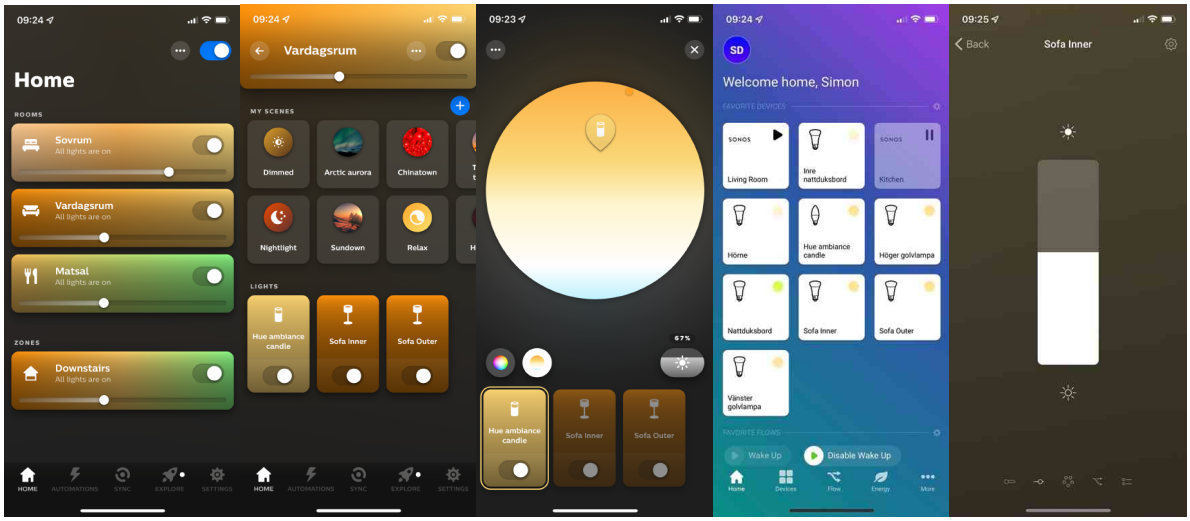


Figure 12. Hue app: home [click room] → room [click light] → brightness [swipe up/down] + color (image 1-3 from left). Homey app: Home [long-press light] → brightness [swipe up/down]

Audio control: Spotify and Sonos

Sonos is a common app for listening to music from different audio services like Spotify by playing audio through Bluetooth or WIFI speakers in the smart home. Most common tasks are to select what to play, usually a playlist, and then what playback source. Skipping, and pausing songs are also important features. Additional features like shuffling songs, liking a song, or starting a song radio are features to be considered for the smart home device. Both Spotify and Sonos share many similarities, mainly divided by their colors used in their respective apps (figure 13).

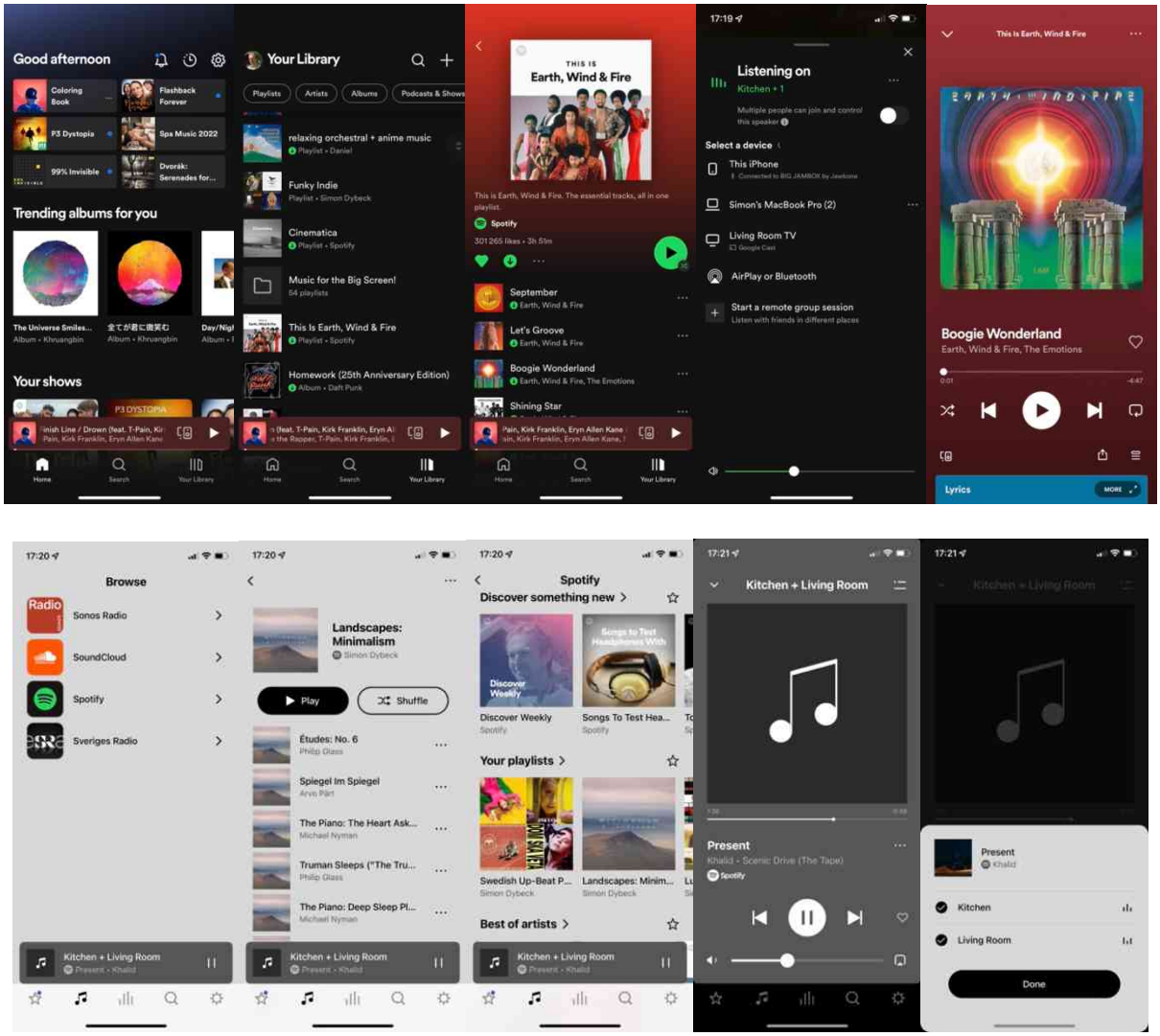


Figure 13. Spotify app (top row from left to right): home [click your library] → your library [swipe up/down], select playlist [click playlist] → play playlist [click play button] → Adjust speakers and volume [click speaker button on player bar]. Last screen show the playing now screen with its many features.

Sonos app (bottom row from left to right): Select media [click Spotify] → home [scroll up/down], select playlist [click playlist] → play playlist [click play button], adjust speakers and volume [click player bar] → see speakers [click send icon] → select speaker [click Living Room + done].

Video control: Netflix

Similarly to audio apps, streaming services like Netflix also let users choose content to play through a playback device like a phone, tablet, computer, or TV. In addition to playing and skipping episodes, it is important to be able to change subtitles or the audio track. For both audio and video streaming services, volume control is also highly important (figure 14). When not using a smartphone to control video services, a physical remote is often used (figure 15).

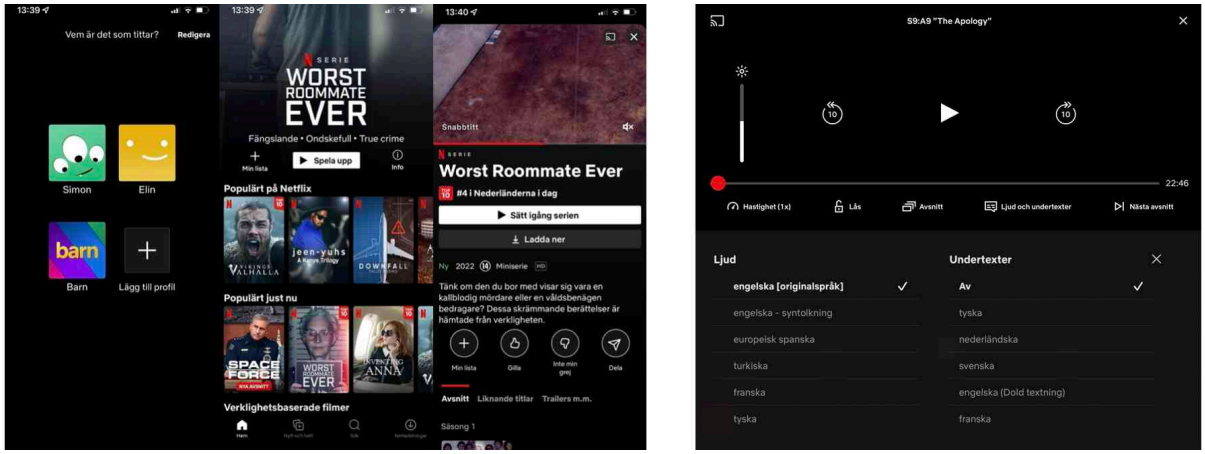


Figure 14. Netflix app: Select user [click Simon] → Library [MD swipe], select item [click click] → play item [click play button], adjust subtitles [click anywhere] → open subtitle options [click subtitles] → choose language [click language].

Tangible control of smart TVs

In addition to apps, typical smart TV remotes were explored. Contrary to the swiping used to navigate in apps, these remotes almost exclusive rely on a so called directional pad (D-pad). The D-pad has left, right, up, down, and a center button to navigate and select content. Typical smart TV remotes are designed to use various apps on a TV like Netflix, HBO Max, Youtube; meaning they need to be designed to work for various uses. To do this, tangible devices are often similar in what components are included to make it easy for users to pick up a new remote and use it from the get go. To provide such a self-explanatory and quick interaction, the amount of buttons and components are often limited (figure 15). Some of the most common possibilities are navigation, volume adjustment including mute/unmute, channel selection, dedicated pause/play buttons, choice of playback device, and sometimes special buttons for voice control or opening apps like Netflix.

Figure 15. (from left to right): Google Chromecast TV, Samsung smart TV remote, Apple TV remote.

Smart home subtasks for lights, audio, and TV

Also relevant to the interaction, is that long-press often is used in apps to mimic left-clicking on a computer to reach contextual menus or options. Also noteworthy, even though all apps share many similarities, is that navigation functionalities might differ between apps as the libraries of content in audio and video streaming services is huge, compared to light apps having a very limited amount of lights to control. No matter the size of the library to navigate, the items are often viewed in a grid as so called cards. Table 2 summarises the most common tasks performed in Philips Hue, Spotify, and Netflix - all important to provide for in the interaction concept. More details can be found in Appendix 9: Common smart home control.

Table 2. Common light, audio and TV tasks a smart home remote.

Light tasks	Audio tasks	TV tasks
Adjust brightness in a specific room	Select media to play from	Select media to play from
Adjust brightness and color of specific light	Play specific playlist	Select user account
Activate specific scene for a room/zone	Select two speakers for playback	Play specific item
Turn off lights in a specific room	Increase volume on speaker	Select device for playback
	Skip song	Change playback item
		Change subtitles
		Increase volume

4.1.4 Device functionality and efficiency

Based on current smart home interaction through apps and remotes, a system function diagram was constructed to highlight what these smartphone and remote interactions generally provide for. To mention a few, the device should present recents and favourites, where relevant. For example, latest played playlists on Spotify. It should be able to adjust range-constrained parameters like volume, temperature, alarm clock, brightness, and color. The device should also provide contextual adjustment possibilities like next/previous, skipping, subtitles, shuffle, and more. In addition to manual control, it should provide triggers to activate scenes and automations. And very importantly, as the device controls multiple types of streaming services for audio and video, it should present available playback devices like speakers and TVs for easy selection. Lastly, the device should be usable in one hand, on a table on a wall (figure 16).

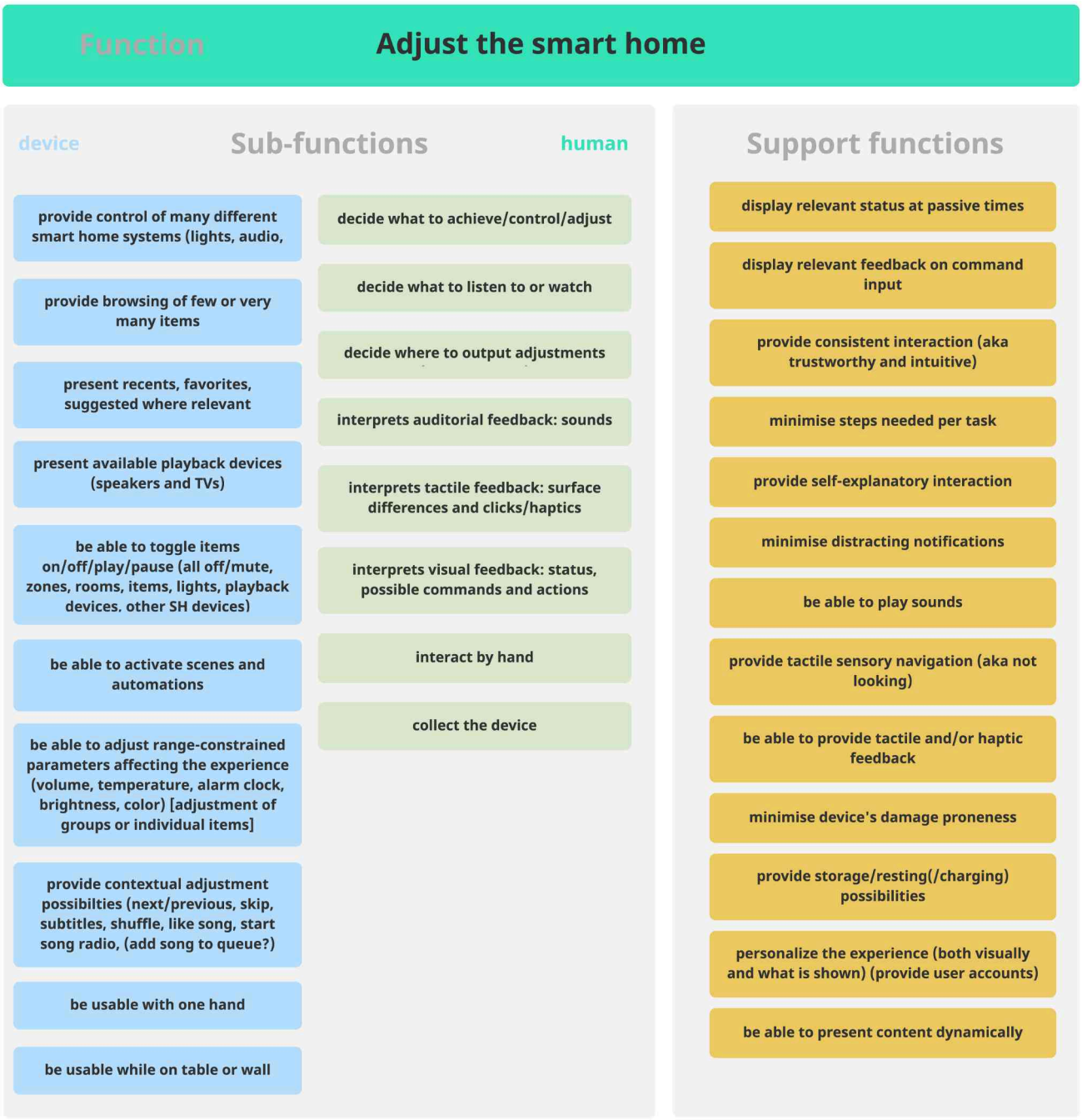


Figure 16. Device functions.

Usability benchmark

To meet the vision goals of making an easy to use remote, these user requirements are deemed important to evaluate for increased usability:

- Want interface that is quick to control (efficient).
- Want interface that provides quick reaction times after input (efficient).
- Want interface that is simple (but still similar capability as phone).
- Want a familiar device to reduce learning curve.

To get a baseline to compare the to be developed concept with, the system potential of using the mentioned smart home apps was measured for achieving similar tasks listed in table 2. The measurement excluded 3 clicks to find and open the apps: 1. Unlocking the phone, 2. exiting the previous app, 3. Click wanted app. With the average System Usability Score being 68, it was deemed reasonable as a baseline (Hjelm, 2021). Table 3 lists the results of the following metrics that were deemed relevant to collect in tests with users:

- Efficiency: clicks total (per system).
- Efficiency: time total (per system).
- Effectiveness: how many sub-tasks completed per system.
- Usability of the whole device experience: System Usability Scale.

Table 3. Baseline system potential of use with current apps (based on table 2 tasks).

	Light control (Hue)	Audio control (Spotify)	TV control (Netflix)	Total
Clicks	9	10	13	32
Time	20	18	20	58
Effectiveness	100%	100%	100%	100%
SUS	[N/A]	[N/A]	[N/A]	68

4.1.5 Common ways of interacting with the smart home

How the most common systems music, lights and TVs are controlled will now be explored in more detail to find common ground for how a device can provide heterogeneous control with high usability. This will be done by evaluating how the selected tasks are performed on common devices, and which components often provide this interaction. For example, a rotary knob is often recognised as for dimming lights and it thus provides a common affordance. The following reflection is based on the commonalities of different subtasks analysed for each app (Appendix 10: Smart home control subtasks). Following, the three most common ways I found of interacting with a smart home interface:

1. Multidirectional navigation. This is used to find items in a big library, meaning tangible items like lights or thermostats, grouping items like zones and rooms, and, digital items like music playlists, songs or TV shows.
2. Range adjustment. After selecting something to toggle on or start playing, it is common to adjust parameters within a set range like volume, brightness, color, temperature, or clock.
3. State change. To adjust how and where items are playing, contextual menus help change subtitles, shuffle, snooze, etc. Also for liking items or starting song radios.

Analysing the diary data, it was shown that the amount of interactions used for each category differed, although toggling devices on and off was the most common for most. Ultimately, I think for a device to have near capabilities of what phone apps can provide, all three of these types of interactions need to be provided for in a good way to support different kinds of use. As different users might use different interaction groups more or less, all need to be designed for with equal importance.

Common ways for navigating

One common way of handling large arrays of content like items in a music app, streaming service, or an online store, is to provide users with infinite scrolling. Infinite scroll is especially popular in social media and requires no extra interaction to view more content; users just keep on swiping which is suitable for smartphones or touch-display interfaces. What is problematic though is that this fluid intake of content is more messy as it is moving at different speeds. Even though infinite scroll is fast, each touch to stop or swipe further also demands an interaction from the user. As an alternative, pagination is also a common and more structured way to show large arrays of content. Instead of swiping, users click to change the page (Kaplia, 2022). These grids of items are arguably better suited for less distracting interactions. Comparing interaction speeds of the two browsing methods, if loading of new content is quick enough, a click to change page should be just as quick as using multiple swipes to reach content - although infinite scroll will always be quicker for scrolling past many items fast to get further down in a long list for example. But, for desirable activities in a serene setting at home, the notion that we reach an endpoint - albeit still leaving us the option of clicking to the next page - provides a sense of control for users ("Psychology in Human-Computer Interaction", 2008). Ultimately, pagination breaks down large arrays of data to increase the ease of use.

Looking at how common apps and systems navigate through large arrays of items, both Spotify and Netflix use multi-directional navigation by allowing users to scroll - or click with a TV remote - through sections vertically. After finding the desired section that could be a genre or recently played items, the user scrolls horizontally to choose the exact item to play. This multi-directional navigation concept can be seen in many other systems and is one of the biggest app trends for 2022 ("Sweetcode", 2022). Philips Hue also use this in their app when a room has been selected to allow users to navigate the scene and lights section (figure 17).

As mentioned, TV remotes that do not have a display often use a directional pad (D-pad) to let users navigate similarly as when swiping, albeit not allowing for the fast scrolling of a lot of sections. Other remotes with small displays sometimes use a scroll wheel or knob to allow users to navigate through vertical lists of items quickly. Sometimes the displays show a few items at a time, while some only show one or two items at a time.

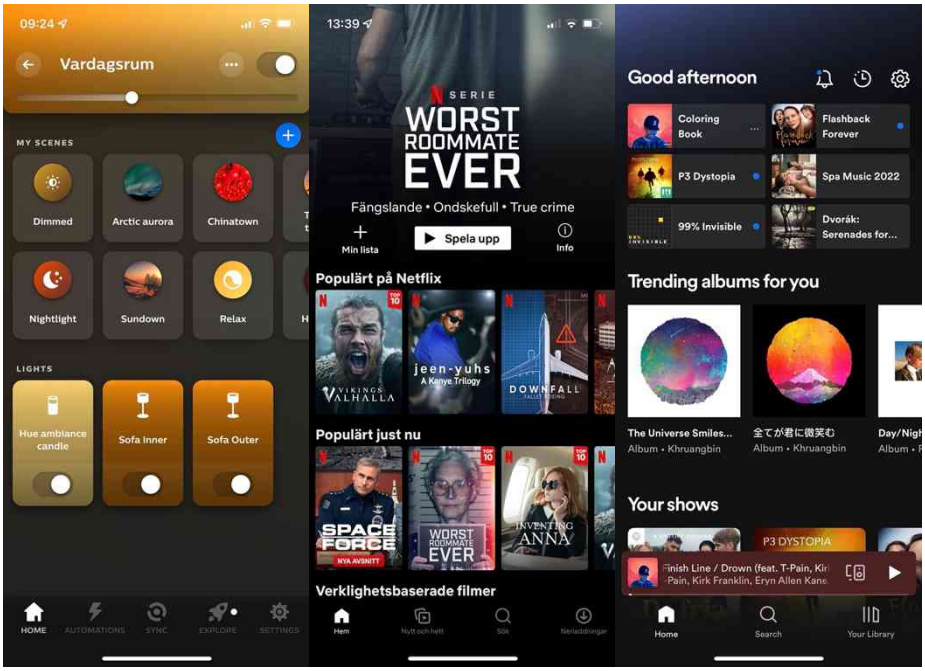


Figure 17. Multi-directional navigation in apps and remotes (Philips Hue, Netflix, Spotify). Scrolling through sections vertically, then scrolling horizontally to select a specific item.

Ranged parameters and contextual options

Volume is often adjusted by up and down buttons, sliders in apps, or by rotating protruding knobs on audio receivers, bluetooth-speakers, or Apple watches. Controlling lights is often done in a similar way, the rotatable wall dimmer being a classic example (figure 18). Similarly, timers, alarm clocks and temperature often use a digital slider, or a physical knob to adjust their respective parameters. When it comes to changing contextual options it is usually done by clicking buttons, either quickly or by use of long-press on smartphones. The more common tasks usually have their own dedicated button while others might be more hidden in menus.

Figure 18. Common remotes and a wall dimmer.

4.1.6 Affordance selection and tests

Affordances are cues telling us how something is to be interacted with. For example, a flat door implies that it should be pushed while a handle affords pulling. In developing an interface that should be familiar, quick and self-explanatory, it is key to have good affordances ("Medium", 2018b). In addition to providing an interface with good affordances for providing an intuitive user experience, adding some novelty to a design is more appreciated by users - if striking the right balance. Studies have shown that finding this balance is most appealing to users as it both provides a familiar and quick interaction while still being interesting and new (Hekkert et al., 2003). This balance if often called the MAYA principle; Most Advanced, Yet Acceptable. Selecting the right affordances in a novel design might give users an interaction they already know, with enough new features that are easy to adopt.

Selecting affordances for the concept

Based on the activities and common devices, the following are potential options for good affordances for smart home control. The selection has been done to allow for the device to be uses as a complement to apps and other controls, meaning that no latching switches or knobs with end points can be used. Although the joystick could be usable, it is deemed to be too wobbly in use (figure 19).

Figure 19. Illustrations of common interfaces (Coutos, 2021).

What is missing though in this image is a resistive slider and push/pull levers which was added to a matrix listing the options for navigation, range adjustment, and contextual options (figure 20). The matrix helped spark brain-drawing on various combinations of navigation and range adjustment tools. To limit the number of categories to draw for, option access was not included as it was regarded as making the concepts more or less minimal, in other words having more or less buttons on the device. To follow the need for simplicity and a self-explanatory design, a balance of using few buttons to only show necessary options was the aim when developing the tangible interface.

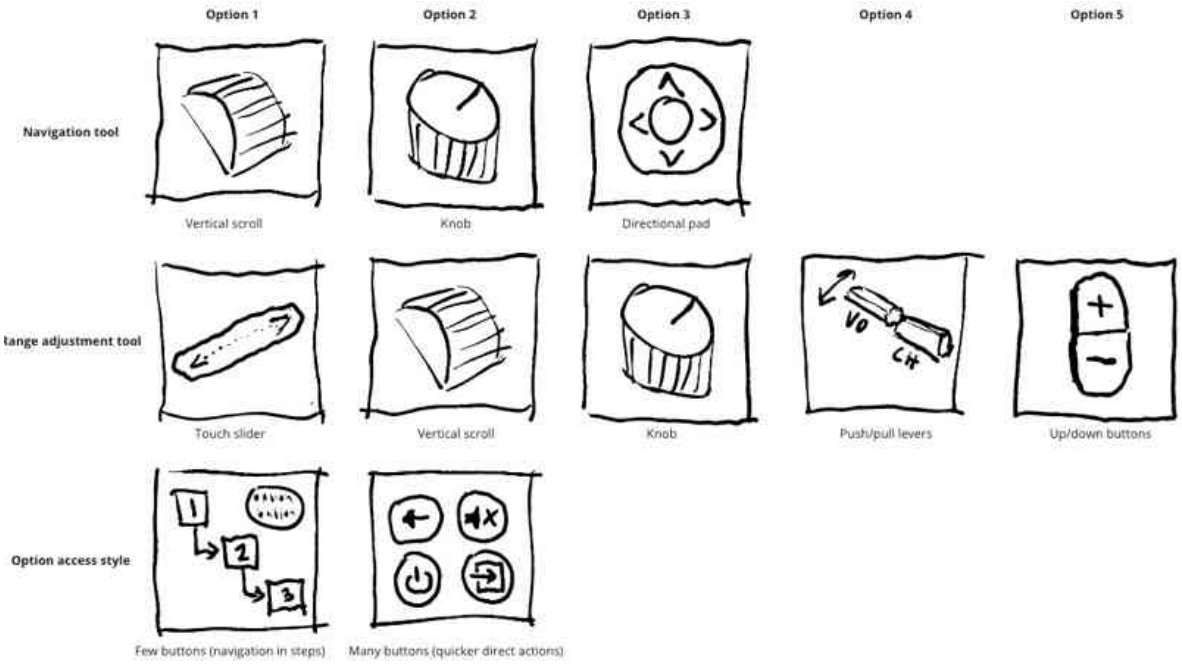


Figure 20. Morphological matrix of common interface components.

In addition, as cards are commonly used as a way to browse items like music or video, and as larger buttons are used to toggle lights like in the Homey app, some kind of grid is needed in the interface design. Navigating such items could be hidden away to reduce the number of interface components but this would risk simplifying the design too much and end up closer to the design of Flic Twist mentioned under section 1.4. For knobs to be usable with a thumb, it needs to be big to demand less of a curved motion but more of a straight motion - much like a DJ turntable can be controlled with a thumb easily while holding the side of the table.

Evaluating the options of the matrix, in relation to existing solutions some conclusions could be drawn to limit the design space. For range adjustments, a knob or slider is quickest as user can choose to adjust just a little, or a lot. To comply with inclusivity in a broader sense than just designing for women, using symmetry in the interface can make the device usable for both left and right handed people. Even though some devices use buttons on the side it is deemed unnecessary as it also might be overlooked, thus impeding the ease of use.

Using two protruding components, like dual knobs, might cause confusion which makes it harder for the user to understand what each component does and will not be considered in the brain-drawing. Just using click buttons is not bringing much novelty or quickness to the concept and is disregarded as well. Lastly, elongated concepts are explored because they are standard for holding a device easily in one hand which also fits with the MAYA principle as something that is familiar to users.

Affordance test with users

The mini-test of affordances showed that the most commonly chosen interface components where the knob(17), slider(16), D-pad (15), and scroll(14). For navigating, the D-pad was the most common by far as all participants chose it. Regarding range adjustments, the push/pull option got the lowest results. Although it is good for saving space, this interface is not as recognisable and does require multiple clicks or long holds to achieve big changes in range adjustments. It will be excluded as an option from the concept development. Most popular range options was the knob, slider, or scroll.

4.1.7 Early interface development and expert evaluation

With the results of the affordance user testing, three different concepts were produced based on an elongated remote shape. Basing all three sketches on the same shape, the variety came from component choice and placement. Another mini-test was created to explain the concept alternatives to users; each with different range adjustors (figure 21).

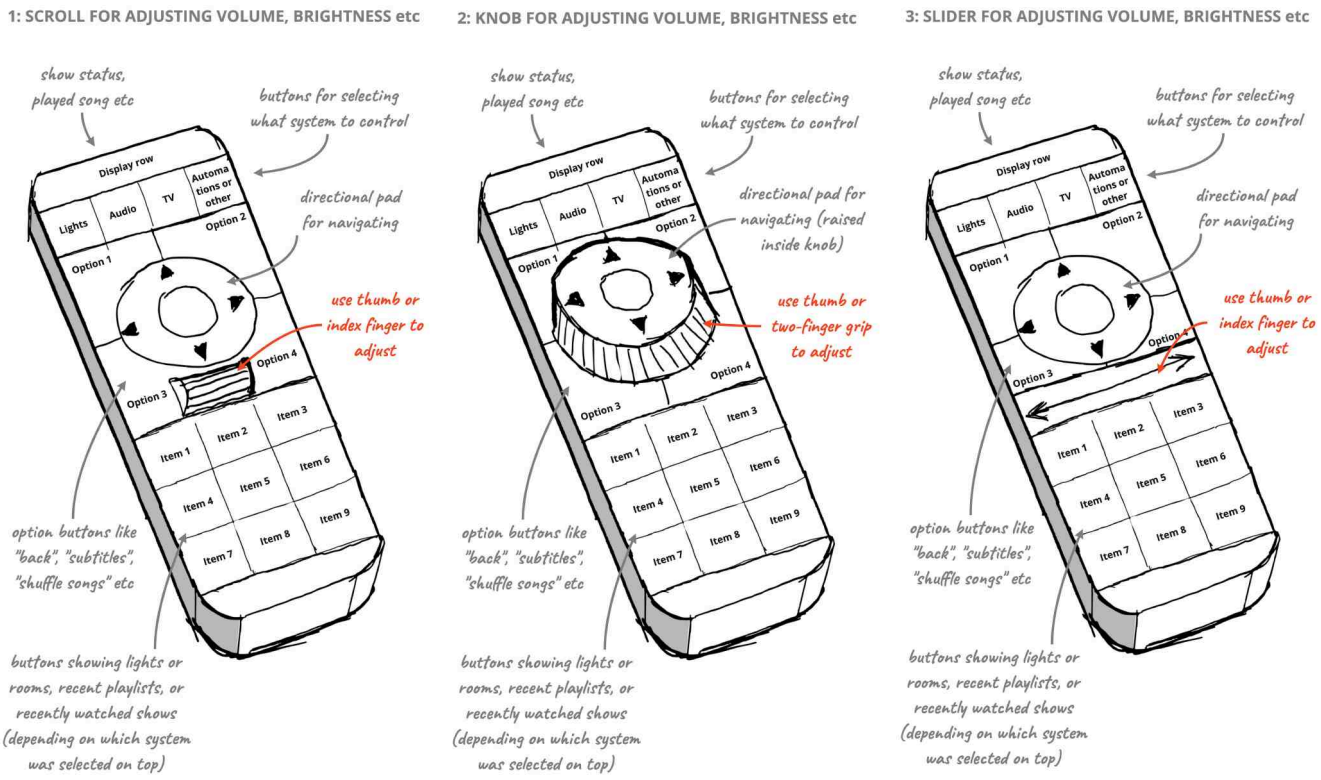


Figure 21. Quick sketches of three different interaction concepts.

The results from the three participating users were quite ambiguous, but all liked the interaction flow of starting from the top and working your way downwards. At this point though, the knob option did seem problematic to users at it could possibly be in the way while a slider felt more simple and recognisable. Scroll was also an option but as this type of component was found to be used in a recently released product called Sofabaton X1, it was excluded. Even though the slider was preferred, one user said that it is hard to say definitively at this early stage what will be the best option as especially a scroll or knob is very tactile and needs to be tested in reality. Given that the round geometry of both the D-pad and knob inside of each other saves space – providing for a small device that fits well in women's hands – it was chosen to be developed further. In addition, as the use of sliding moves in apps on our phones are less tactile choosing it might provide a too phone-like experience. Even so, using a slider was deemed as a good backup option if the knob concept would not be appreciated by users. Hence, a D-pad put inside a protruding knob was selected for the concept to allow for users to easily navigate and adjust ranges of parameters. For the full responses, refer to Appendix 11: Quick sketch evaluation.

Now, a first draft of the user interface was designed in Adobe XD (figure 22). Using the previously sketched remote as a foundation, a minor change was implemented to make contextual buttons more easily reached just below the knob and D-pad. These new contextual buttons were designed to toggle between different functionalities, or toggling different pages for browsing items. To be simple and self-explanatory, all button areas of the interface change its content dynamically according to user actions. Aiming for a nomenclature and symbolic use that is more natural to users, no matter which system they interact with, is preferred by users (Pillan & SaraColombo, 2017).

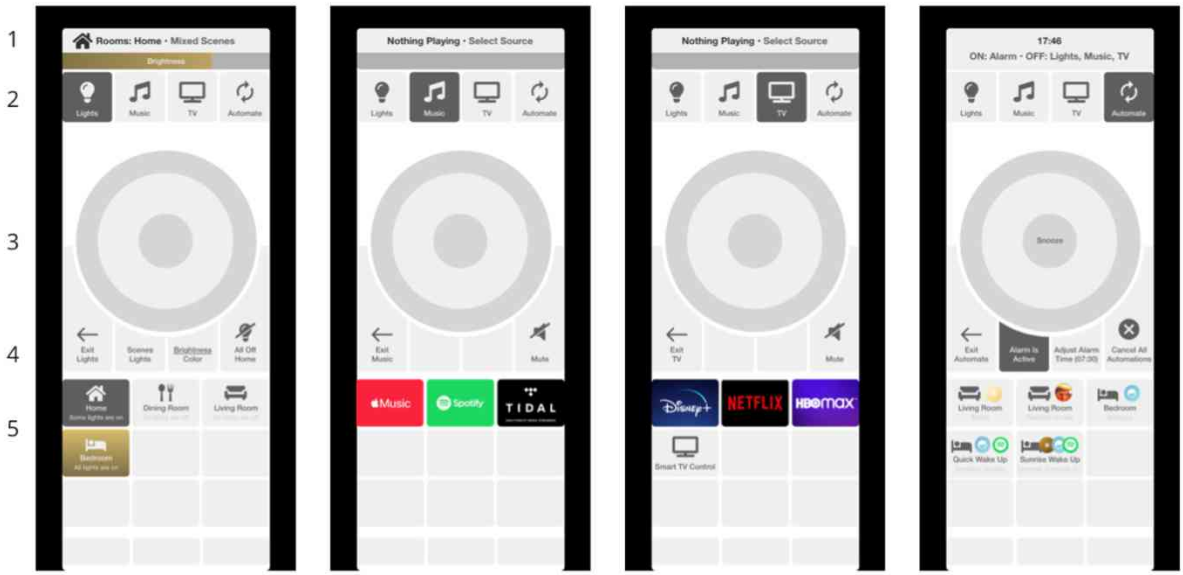


Figure 22. shows the different areas of the interface: 1. Status bar, 2. Type select, 3. D-pad and knob, 4. Contextual buttons, 5. Content grid.

Heuristic self-evaluation

Before handing over a digital prototype of the proposed interface, a self-evaluation was completed to make sure no big flaws were found. The self-evaluation, based on Nielsen's 10 Usability Heuristics (figure 23) proved that most were taken into consideration except for 9 and 10 who will be designed for at a later time. In this early draft of the interface, it was found that more work is needed to make sure feedback is shown properly, and to make the UI design clear.

Figure 23. 10 usability heuristics (Newbie Heuristic Evaluation Mistakes To Avoid, n.d.).

Heuristic evaluation with experts

According to one of the experts, the project seems promising, adding that the UI work seems interesting and thoughtful. Another expert noted that as the device will be used daily, users will quickly become experienced, making the interaction efficient and close to its system potential. The highest summarised result per heuristic was 1,75 while only one individual response was rated 4, meaning that issues is imperative to fix before release – deemed not as a problem this early in development. The overall usability score was cosmetic (1,1) which ultimately means that the general interaction flow of this early prototype was accepted as highly usable by the four UI/UX experts (figure 24).

Figure 24. Severity scale used in heuristic evaluations.

Issues to address according to the experts was that there were some inconsistencies between how contextual buttons were used for the different systems. Also, the use of a dark grey color to indicate a selection was not appreciated as it could be interpreted as something being turned off. Lastly, to allow for user control and freedom, there is a need to provide for selecting playback devices before or after choosing an item to play. All results of the heuristic evaluation can be find in Appendix 12: Heuristic expert evaluation results.

4.1.8 Summary

This phase of the project explored how common apps and tangible devices are used to control smart homes. The selected concept design based on an elongated handheld shape with a combined D-pad and knob is meant to provide a familiar yet novel and quick way of interacting with smart home. The metrics clicks, time, effectiveness, and System Usability Score was selected to benchmark the concept with current solutions. Lastly, the chosen design was evaluated by users, myself, and experts to make sure the interaction design has high usability. Results mainly demanding refinement of how contextual buttons are interacted with to be more coherent. Below, a summary of key insights from this stage.

Main problem

- How can a tangible device be developed to achieve common smart home tasks more efficiently and effectively than using apps? (tangible in what way).

Smart home devices

- Smartphones are used most often for its high capability while remotes are used as a complement for its ease of use and efficiency.

Smart home subtasks

- Adjust light brightness/color and toggle on/off state/scenes.
- Choose media source, select from recent playlists, and have basic control of playback like which speaker, pause/play/next/previous, and shuffle.

Interaction typicality

- Navigation uses multidirectional swiping or clicking by touch screen or D-pad.
- Ranged parameters like volume/brightness often use clicking, sliding or rotating.
- Key contextual options like mute have dedicated buttons.

User and expert evaluation

- Users liked the slider or knob for different reasons; testing physical prototypes only way to evaluate how well it is appreciated by users.
- Experts appreciated the thoughtful UI, giving it a low usability severity score.

Usability goals

- Quick: few clicks and short time needed (32 clicks and 58 seconds).
- Self-explanatory: how many tasks are completed by first time users (100%).
- System Usability Scores above 68.
- Device needs to be as usable for left and right handed people.

Most notable utility goals

- Be able to present content dynamically.
- Provide consistent interaction across systems.
- Display relevant status at all times.
- Provide browsing of many or few items.
- Present recents, favourites, etc for each system.
- Provide quick possibilities to toggle on/off states or adjust ranged parameters.
- Provide contextual adjustment possibilities.
- Be usable with one hand being hold, on a table or on a wall.

Exclusions (to be done in companion app)

- Allow users to customise the interface for their preference (e.g., screen brightness, volume, font, and font size adjustment).

Guidelines for design and aesthetics

- Use familiar components and interaction design
- Use a familiar device shape suitable for one-handed use.
- Top to bottom interaction flow adhering to usability guidelines.
- Device should include status display, type select buttons, D-pad, range adjustor (knob or slider), and item grid buttons.

4.2 Interface design and testing

Building upon the task and affordance mapping with insights from experts, this stage focused on producing a low-fidelity digital-hybrid interface to mimic a tangible device while allowing for quick prototyping with use of Adobe XD. After improvements were made to the UI design, a prototype providing for selected tasks for control of lights, audio and TV was tested with users. In addition to evaluating usability, ergonomic factors like size and button shapes were evaluated. Comparison of other smart home remotes and discussions about aesthetics were had to further guide the development of a familiar and efficient smart home device. How range parameters like volume, brightness and color should be adjusted, and how feedback is shown, is central to shape how the design will look.

4.2.1 Problem

- How can a tangible device be developed to achieve common smart home tasks more efficiently and effectively than using apps? (making it tangible)
- How can a device be shaped to allow for good usability and ergonomics for women?

4.2.2 Digital prototype improvements

The results of the heuristic evaluation done by UI/UX experts helped guide work for improving the digital prototype to make it even more refined before performing user tests. The feedback on the most applicable heuristic guidelines in combination with aggregated UX ideas were used as a foundation for the work done in Adobe XD.

Although it was not entirely clear how well the top status bar will be perceived by users, there was a need to change the color scheme and typography to make selections less ambiguous. Mainly, this was done by changing the previous dark grey select color to black, deciding to stick to a grayscale design as much as possible for two reasons: 1. It is too early to lock into specific color choices, 2. Having a third party like Homey acquire the design would bring a new set of color requirements to match their company profile. In addition to using a darker color, the typography and use of geometric elements in contextual and grid buttons were used to further emphasise that a selection had been made. Another important area improved upon was what contextual buttons do and how they communicate it - mainly eradicating inconsistencies to make the four buttons follow the same pattern. The outer left for back/exit, middle left for cycling item sections like lights or scenes, middle right for cycling playback devices and options, and the outer right for mute/turn off (Figure 25).

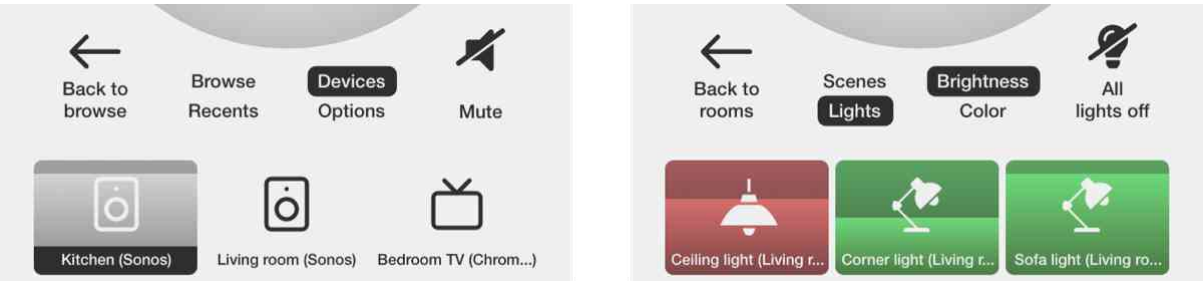


Figure 25: Current page shows Devices for playback; clicking 'Browse - Recents' would bring the user to see recent playlists while clicking again on 'Devices - Options' would show options related to music playback such as 'Like', 'Shuffle/Repeat', 'Start song Radio' (left). Another example is how the middle left context button have selected 'Lights' while the middle right button has 'Brightness' selected, meaning any rotation to the knob would change this parameter of whatever lights are selected in the grid.

To provide better user control and freedom, the previous prompt for users to select a playback device if none was selected was removed. Instead, if no device had been selected before playing videos or music, an internal speaker of the device will play the audio track, providing feedback to the user that they have not yet selected a proper device while simultaneously giving them feedback that they successfully played something. Additionally, the 'Devices - Options' button would hint at interaction through a pulsating color or similar for a short while. Aiming to be intuitive and easy to use, the interface have been designed to have clear enough explanations for users to learn the device quickly without the need to use a manual or similar. With elements of the design updated, a lot of time and effort were put into making it possible to click around the prototype to provide for all selected tasks - and some variation if users tried to achieve tasks in a different manner or just wanted to click around. Figure 26 shows how the device shows different feedback, button symbols, and items in the grid to provide users with only the essential. On the left, users have just clicked Lights, the device automatically selecting the whole home so that the user can dim the lights instantly by rotating the knob. Toggling the brightness/color, the user can now adjust the color value of the Home. In the middle right, the user have just clicked Stream, providing a selection of streaming services to choose from - yet at this point the user can adjust the volume of what is already playing in the home. Selecting Spotify, the user gets latest playlists presented in the grid, allowing for quick play of appreciated music or podcasts.

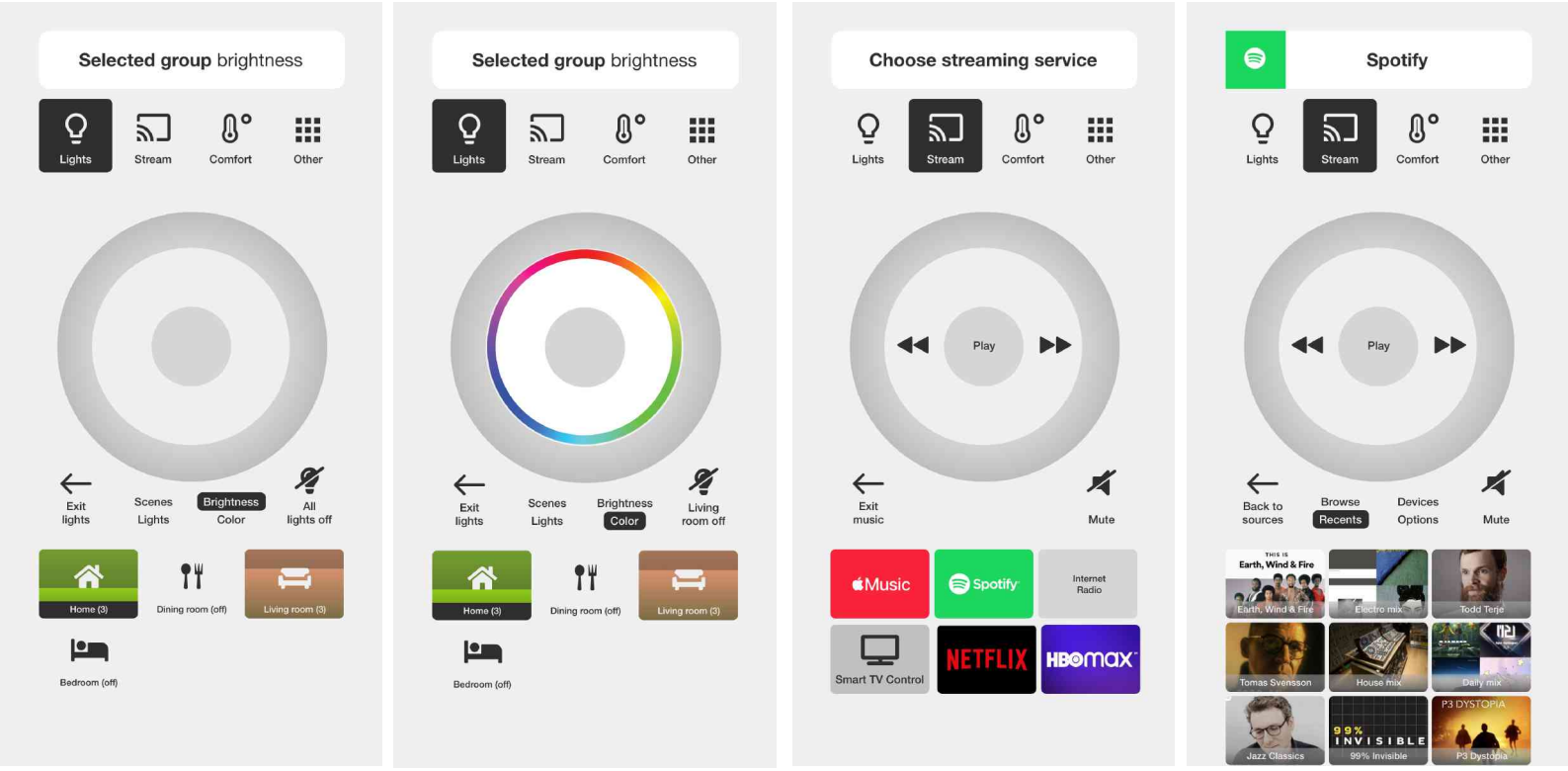


Figure 26. This is the slightly updated interface. For the version used at this stage in the project, refer to Appendix 13: Interface design v1.

4.2.3 Self-validation of the digital prototype

Prior to testing the interface with users, the design was compared with the requirements collected up until then, and evaluated by cognitive walkthrough used for the selected TV, lights and music tasks (Table 4). The tasks to evaluate were chosen according to user needs with the addition of common contextual options to properly test how users complete such tasks and handle going back and forth between deeper layers of the interface design. Having to go through each step of the interaction in the cognitive walkthrough provided some valuable insights.

In general, rotating the knob to adjust lights, volume and color might not be understood in the digital device but ought to have a more clear affordance on a tangible device. Also, how the back button is designed for users to step back from contextual pages like devices or options might not be clear for first time users. With TV control selected as the first system to be controlled by users, they might struggle at first with understanding the toggling nature of the contextual buttons. Hence, finding devices and language options might take some time but once that has been found and tested, it should be quickly done every consecutive time - no matter if it is done for TV or audio control as the latter is very similar to the former. As audio tasks will be performed last, it is believed that this will go faster given that users already have tried similar interactions for the TV tasks. With light control differing a little bit as rooms and lights only have the option to control brightness or color its intended use might not be totally clear for first time users.

Table 4. Selected tasks for user tests.

TV	Lights	Audio
Play 'Our Planet' on Netflix on the Bedroom TV	Turn on the Dimmed scene in the living room	Play your recent Earth, Wind and Fire playlist on Spotify. Select the Kitchen speaker.
Change to Seinfeld and show Swedish subtitles	Dim the Sofa light in the living room, then change its color	Increase the volume and like the current song
TV	Turn on bedroom, then dim lights in bedroom	100%

4.2.4 Ergonomics evaluation and digital-hybrid test

The goal of this user test was mainly to evaluate the overall usability of the interface concept, and the coherence of lights, audio and video interactions; comparing clicks, time, and effectiveness with the measured system potential. Another key aspect that was evaluated is how the proposed concept feels to hold, interact with, and to pick up. Exploring various button shapes was also accomplished to aid detailed design. Additionally, the opportunity to meet with users physically provided a good time for discussing some basic aesthetic preferences like color and device shape options (Figure 27).

Figure 27. photo of all mockups and prototypes used. Hybrid digital prototype (left), size mockup (middle left), button examples mounted on early mockup (middle right and right).

Effectiveness and usability results

Most completed the tasks on their own but some help was needed occasionally to help users with contextual subtasks like showing subtitles or liking a song; usually by telling users that a button they have used previously was to be used again. With users getting help for some tasks being deemed okay for first time users, the total completion rate for this test environment was 100%. Discussions about the interface, and reviewing the System Usability Score (SUS), makes it probable that users could have achieved these tasks on their own if given a fully functional interface. Even though users did take quite a lot of time to complete tasks, and with twice as many interactions, the SUS score is above the average 68. The

overall feeling when talking to the users where that everyone felt that they would be able to use its basic features instantly, and quickly learn its more advanced features. 77,5 means the usability is good, even closing in on excellent at 85.5 (100 being best imaginable) (Smyk, 2021). Selecting a device for playback was not always found, but once learned for the TV tasks, it was found easily when playing music, meaning learnability is high. For this early digital-hybrid prototype the SUS results highlighted a promising interaction design.

Looking at the individual questions of the SUS - especially those mostly related to the goal of creating a self-explanatory and simple interface - four users responded the lowest or next highest on a scale of 5 for the following: 4. I think that I would need the support of a technical person to be able to use this system (not needing), 6. I thought there was too much inconsistency in this system (no inconsistency), 7. I would imagine that most people would learn to use this system very quickly, 10. I needed to learn a lot of things before I could get going with this system (not needing). When asked about the simplicity, familiarity, and self-explanatory nature of the interaction, results varied - although not with any excessively bad results. Regarding the quickness and trustworthiness, the device interaction received good results (Appendix 14 - System Usability Scale and Semantic scale).

Qualitative results

One user commented on the need to have control of the smart home even when internet does not work (something not possible with the Sonos app for example). This user also appreciated that the product was designed for serenity, aiding a sense of calm and disconnect. The heterogeneous design was appreciated for its ease of use and self-explanatory nature, allowing users to quickly control what they want instead of having to look for a specific app name as is commonly done on smartphones. The non-smart home user expressed that she would happily use it in another person's home if asked to control lights or music when visiting. How the start page could be personalised to provide a custom view for users was also appreciated to increase convenience.

When users tried to rotate the knob while it was placed on a table or wall, users felt it could work well if the friction was calibrated well in the knob. As presumed, users expressed that having a physical mockup with a protruding knob makes the affordance more clear. Next, users got to pickup the device and evaluate it's ergonomics - all agreeing that the mockup felt light and comfortable in the hand. The curvature underneath was liked for lifting up the device easily. Although most users felt the size mockup was a bit too long, there were also some who thought it good to have some extra space without buttons for resting the palm on. Regarding the thickness, all expressed that a thinner design, if possible, would be more aesthetically pleasing. The width was deemed good as users did not want it to become too narrow, something that would lead to even smaller buttons and hard to read texts.

When holding the device, users got to try and rotate the knob with their thumb, which was deemed to work okay. Reach tests to the top buttons was not as easy though but deemed

reasonably compromised as one does not interact as much with those buttons. Discussing range adjustments, opinions about the knob varied as some liked the tactility and familiarity of using a step-less knob while others felt it might be in the way and look awkward. Users said that a slider also could be a valid option, especially for its believed aesthetic benefits, but also for its ease of use with a thumb when holding. For using the remote on a wall or table, the knob was mostly deemed the better option.

Testing some various button shapes proved difficult to evaluate as the 3D printed shapes were slightly more exaggerated and had a rougher surface than existing remotes. Also, users had conflicting opinions on what kind of button design was preferred; half liked concave buttons while the other half liked convex buttons for its feel and look (figure 28, top). All liked the symmetrical options best though, and appreciated the use of real tactile buttons instead of a touch display. Then, users were given some real remotes to discuss feel and aesthetics, or as also called, surface delight. The Google Chromecast remote felt a bit slippery due to the shape and material while the black beamer remote felt better in the hand. In general, rubbery buttons were more preferred than hard plastic. When asked about opposing qualities, all preferred a smooth, rubbery and bright device. The polarities squared-rounded and decorated-minimal received a neutral score. Being simple was also important for most (figure 28, bottom).

Figure 28. remotes (top). Semantic differential scale on product qualities (bottom).

Benchmarking with apps

Click amounts were quite similar across each task group with an average of 64 clicks split among all users, excluding the pilot test. Regarding time, two users spent a minute or two longer on the tasks, resulting in an average of 270 seconds to complete all tasks. Comparing these results with the system potential calculated when achieving the same tasks on the same interface showed that for users to complete the tasks, twice as many interactions and 5 times as many seconds were required (table 5). Having calculated the efficiency of the new interface being slightly more efficient than using various apps, how well such an interface performs will depend highly on the context and users. Having a higher system potential is a good starting point for providing a convenient experience for users, and with users appreciating the simplistic and self-explanatory nature of the interface, it is probable that new and experienced users will achieve tasks with higher effectiveness than with a mix of smartphone apps.

Table 5. Summary of results (in order of tasks group performed). The SUS average of 68 was used as a benchmark for all the app tasks.

	TV app (Netflix) System potential	Light app (Hue) System potential	Audio app (Spotify) System potential	All tasks in apps (Netflix, Hue, Spotify) System potential	All tasks System potential device	All tasks User results device
Clicks	13	9	10	32	30	64
Time	20	20	18	58	51	270
Effectiveness	100%	100%	100%	100%	100%	(100%)
SUS	[N/A]	[N/A]	[N/A]	68	[N/A]	77,5

4.2.5 Summary

Having developed the UI in detail - and self-evaluated it before testing with users - the work proved to be worthwhile as the System Usability Score was high with good remarks from users. Benchmarking the device to apps and system potential was still a bit off, but given time users acknowledged that the interaction would become quick after a few uses. Overall, the concept achieved good or neutral scores for evaluated qualities of the project vision (table 6).

With the choice of using a knob being the most contested feature, use of any type of slider could be an option to improve the experience for users. For example, a circular slider area around the D-pad could be used - or just a vertical slider underneath. For now, the knob is chosen for development as the combination of the D-pad and knob has not been seen with competitors, being able to bring something new if implemented in a good way as the knob also adhered to typical affordances like adjusting brightness or volume on existing interfaces.

Table 6. Summary of results in relation to the vision qualities.

Qualities	Score (out of)	Comment
Simplicity	SUS: 77,5 Semantic: neutral	High SUS but feedback and clarity needs more work
Self-explanatory	SUS: 77,5 Semantic: neutral	High SUS but feedback and clarity needs more work
Quick	Twice as many interactions, five times as long time. Semantic: good	Compared with system potential, but deemed to improve quickly after use
Familiar	SUS: 77,5 Semantic: neutral	Users felt this would increase on a real product
Trustworthy	SUS: 77,5 Semantic: good	

This stage discovered 23 new requirements, mainly about device size, but also some additional functionalities requested by users and discovered by me when analysing the results of the user tests. Some of these are the wish to be able to select a specific song from a playlist, install without a phone, and to function without internet connection among others (refer to section 3 of Appendix 8: Needs and Requirements). An elongated remote was deemed fitting to be ergonomic and convenient for the women users. Below, key design guidelines for developing the functional prototype in the next chapter.

Design guidelines

- Smooth, rubbery and bright device for a desirable aesthetic.
- Elongated, narrow and thin device for comfortable holding.
- Use the current, highly rated version of the UI.

5.

Visceral level

Exploring the appearance and feel of the tangible smart home interface

This chapter concerns how the intended concept was developed to be tactile and experiential, providing a good glimpse of how smart home control can be different than todays smartphone-heavy interactions.

5.1 Delivering a tactile experience

According to Norman's three levels of design, the visceral level concerns itself with appearances ("Visceral Design", n.d.) and impressions; creating emotions that are felt deeply and not the result of active thought ("Collins Dictionary", 2022). Given the vision to develop a smart home remote that is tactile and enjoyable, this phase is very important to make sure that users have a good experience with the product, that it is delightful to use. As this level of design refers to the perceptible qualities of an artefact, the focus is to develop an experience that positively stimulates visual, auditory, and tactile senses ("Interaction Design", n.d.). While previous stages made sure that the right problems were solved for in a structured way with testing of the functionality and usability of the interface with women, the visceral level provided for exploring creative prototyping to make sure that a semi-functional prototype could be presented to users and tested.

5.1.1 Problem

- How can interaction with the tangible device provide increased visual, auditory, and tactile satisfaction compared to smartphone use?
- How can a smart home remote be shaped to be used with the developed UI, and also comply with size requirements?

5.1.2 Initial tactility tests

With tactility being one of the vision qualities, not only is the material and surface finish of a product important, but also the feel of clicking on tactile buttons. By clicking and measuring various parameters through a qualitative self-test, some insights were found about what can be good to consider to provide a pleasurable user experience (figure 29). The self-evaluation showed that buttons with a loud click both sounds and feels cheap, also limiting the option for users to allow for muted clicks if wanted. If using buttons with low auditory feedback, a speaker could be used to add additional and variable sounds when wanting to provide better clarity in what action has been performed.

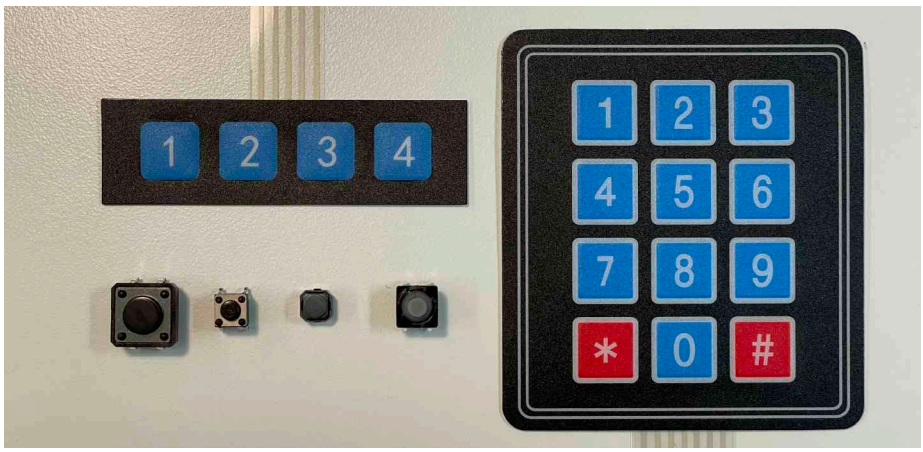


Figure 29. Various tactile buttons.

When comparing the feel of clicking on these buttons with an Apple keyboard, having a low sound and semi-distinct tactile feedback, it might be possible that prolonged use makes the tactile switches a bit softer, and that using a casing gives users a larger surface area to press, making it less demanding to press. Notable is that auditory and tactile feedback can be experienced as quite different depending on how buttons are mounted and which material is covering them, meaning that material and build choice will play an important role in the final design.

According to my evaluation, the best option was the 4 button keypad - and the two soft small buttons. The keypad felt good but was a bit too loud. the soft round buttons required little force which was deemed good to comply with user needs of having a quick and easy to use device. Being quite wobbly could prove problematic, or it might get eradicated as a cover is put on top. The square soft button had a distinct and sturdy tactile feedback but did require more activation force. The deflection of these buttons ranged from 0.2-1.5mm; each end of the spectrum with its benefits and drawbacks. A short deflection saves space but will provide less of a tactile move. A long deflection might provide a more clear feedback of the button having been pressed. One issue with the softer buttons is that they do not have a clear click to indicate exactly when the button has been pressed, something that is also felt like a tiny vibration in the clicky buttons. To improve the clarity of button presses, both auditory and haptic feedback could be added to provide an enhanced and customisable experience (table 7).

Table 7. Evaluating the buttons' deflection, activation force, auditory and tactile feedback.

Type/ parameter	Deflection	Activation force	Auditory feedback	Tactile feedback	Comment	Rating (1-5)
Keypad (4)	0.2mm	low	medium	medium distinct	a bit too loud but with nice distinct tactile feedback	4
Keypad (4x3)	0.2mm	medium	low	low soft	no sound but feels very cheap and non-responsive	1
Tactile switch large	0.44mm	medium	loud clicky + wobbly	high distinct	feels cheap with a wobbly and loud click	2
Tactile switch small	0.27mm	high	loud clicky	medium distinct	quite distinct but very loud	3
Soft square button	1.43mm	high	low more distinct	medium semi-distinct	less wobbly and distinct	5
Soft round button	1.5mm	low	low less distinct	medium soft	a bit wobbly but requires less activation force	5

The results of the tests gave an initial starting point for developing the prototype in a small form factor, close to the wanted dimensions of 15 mm high, the height of the mockup tested with users previously. With this first more extensive testing done, it was deemed too early to make a definitive selection of buttons – also due to the fact that there are hundreds of different button types to find online – as many other parameters must also fit to comply with the overall requirements of the product vision. Ultimately, even though exploring and testing more different buttons could further improve the tactile experience, just having a tactile pushback is already much better than using a touchscreen. Hence, the following Arduino build focuses on selecting good enough components to make sure users can tryout the functional prototype.

5.1.3 Arduino prototype

Surely, a custom designed circuit board with integrated buttons will make it possible to reach a height of 10-15 mm on the device, but for Arduino prototyping some extra space is needed to connect wires and components. Hence, it was deemed okay to build a functional prototype of the size 140 × 60 × 20 mm to fit the most necessary components. Given the unique combination of components to provide for a novel user interface experience, the details of what the prototype consists of will not be explained in this paper. Focus areas for the development is to make sure that the remote can be held and clicked to initiate changes to one or multiple smart home devices. It is also important to allow for rotating the knob to adjust brightness, color or volume.

5.1.4 Product aesthetic

Using clay for exploring the shape of the product, a replica was made of the mockup but with refined fillets to make it fit better in the palm (figure 30). Second, another model was made with a more dynamic bottom shape to make it even easier to pickup the device; and to make the hand more centrally aligned on the device when holding it - all of this while keeping the corners of the device relatively sharp to allow for users to push the buttons while the remote is on a table.

Figure 30. Clay models of the device.

With the two variations of the general shape set, a knob and D-pad was modelled to get a better tactile feel of a matte material – something asked for by users – compared to the previously 3D printed semi-glossy plastic knob. Additionally, user tests showed that some had missed the feedback display on top which led to an exploration of adding a more distinctive feature at the top of the device by tilting the upper 10 mm a few degrees upwards. This way the display would be slightly more angled towards the user, while also providing a parting line towards the type buttons below. To mirror this tilt, the bottom part of the device was angled to be in parallel with the tilted display area. This would also provide for less of a bulky feel in the palm of the users hands.

As buttons will change appearance, and sometimes not show anything at all, it is reasonable to provide a button design that is discrete but still distinguishable without looking. This way user requirements of a minimal and simple aesthetic can be achieved. This also makes the device more hygienic as there will be no separate buttons surrounded by crevices; the whole face of the product will be one continuous surface except for the knob that needs to rotate freely. As users had indicated that a minimal design is appreciated to support simplicity and an appealing aesthetic, combined with the notion that developing a design that is not adhering to simpler geometry requires many more iterations to find a good balance between elements to provide a good gestalt, it was better to opt for the blocky design in this project. Next, the final rendition of the concept is presented.

5.1.5 Sally: *Your* Smart Home Ally

This is Sally. Your smart home ally. She is bright and slender. Perfectly comfortable in a woman's hand. Very capable but still subtle in its design. The knob, allowing for quick and pleasant control of light brightness, volume, temperature and more. When not in use it only displays what is necessary like the time or status of your smart home in the top. The device provides quick and self-explanatory control of lights, streaming of video and audio, temperature, and all your other smart home devices (figure 31).

Figure 31. Concept presentation and features.

To control lights for example, one easy click and rotation dims all lights in your home. Two more interactions and you have selected a room and changed the colors. The device changing its display accordingly to provide relevant feedback of its actions. If playing music and no wireless speakers are selected, Sally plays from its integrated speaker to hint to the user that they should select a playback device.

The device works seamlessly with all your smart products and apps and installation can be done without a smartphone. Even though it has a long battery life, a wireless charging station with a magnet is provided to make it easy to store the device in a convenient place - maybe in the hall on a wall, or on the bedside table. The knob is very quick, but also precise; giving users the ability to smoothly or rapidly change the lights or volume in the home. The device is personalised by connecting with your Spotify, Netflix and other services - recent playlists and TV shows are easily shown in the grid for quick access. The grid being empty when no system is selected to leave Sally looking minimal, fit for any interior (figure 32). Long-pressing any of the upper buttons loads 1 of the 4 user profiles so Sally shows the right streaming services. By including an alarm clock, it is easy to leave the phone behind and use Sally to control your smart home from the bedroom.

Figure 32. Detail renders of D-pad/knob and grid buttons.

With the included app, that you do not need to use as the remote automatically connects to the devices in your smart home, users can customise their experience to fit their needs by adjusting settings like text-size if for example elderly people want to have better readability. The device has a semi-rubbery surface to give good grip and a pleasant feel. The seamless button design provides a hygienic surface that is easy to clean. The powerful speaker is not only for feedback, it can also be used to play some lovely radio when enjoying you breakfast on the balcony. And lastly, if you would lose the device in your home, just open your smartphone app and click Find my Sally. She will play a loud sound so you can find her. Additional renders of the dynamic nature of the concept presented in figure 33.

Figure 33. Three different uses of the device. The left image showing how it looks when not in use. The middle showing lights selected. The right one controlling streaming services.

5.1.6 User validation

As a final validation, a simple test with the functional prototype, and discussions regarding the smaller high-fidelity prototype, was performed with three users (figure 34). Comparing with the results from the previous user test (Appendix 14: System Usability Scale and Semantic scale), trustworthiness and quickness got similar results while the self-explanatory nature of the concept slightly improved according to users. For the final test, users really felt a big improvement had been made to make the remote feel familiar and simple - as expected by the same users in the previous test with the digital-hybrid prototype (table 8).

Table 8. A positive number meaning the users rated the prototypes as being more aligned with the first word in the listed opposites.

	Digital-hybrid test (average per person)	Physical user test (average per person)	Difference
Simple vs Complex	0,8	2,0	1,2
Familiar vs Unfamiliar	0,3	1,7	1,4
Trustworthy vs Unreliable	1,8	2,0	0,2
Quick vs Slow	1,8	1,7	-0,1
Self-explanatory vs Cryptic	0,8	1,3	0,5

Figure 34. The smaller high-fidelity prototype and the larger functional prototype (left). The functional prototype being tested by a user (top right). The high-fidelity prototype being evaluated by another user (bottom right).

Users also got to review how well they thought the remote fit in their hand, and how well they reach buttons and are able to rotate the knob. All three participants liked the size and shape, saying it was comfortable to hold and use. Although reaching the upper buttons on the device required to change the grip on the remote, none felt this was anything that would trouble them - they already all have to reach further when using larger smartphone devices every day. While testing to rotate the knob to adjust the brightness, all users felt that the circular, dimmer-like design could work for a final prototype - given that the right amount of resistance and grip was provided. One user for example preferred some more resistance in the knob to not accidentally rotate the knob when not wanted, and to provide more of a high-quality sturdy feel. While testing the functional prototype, one user thought the visual light feedback on the remote was really interesting. She really liked it but couldn't say exactly why. She only knew it differed from what she was used to with her phone, and that she appreciated it.

When discussing if the remote would be quicker, easier, and more delightful than using a smartphone and various apps, all users were positive about the concept. Regarding quickness, two felt it would be just as quick and probably quicker as one does not need to unlock the phone and browse through apps. The third felt it might be equally quick but with the remote, users do not need to be disturbed by other things on the smartphone, in turn making the remote quicker overall. This was something all three touched upon, the benefit of not needing to use the smartphone and risk getting disturbed by notifications and mental distress of just using the smartphone. All three felt it was easier due to the fact that all smart home systems was collected in a neat and simple way - especially for elderly or those not used to using smartphones. Finally, all users truly felt it would be more delightful to use the

remote because it meant they could skip the phone. When probing about how delightful the actual interaction with the components of the prototype was, no clear opinions were expressed by the users. Lastly, users were asked if they might want to buy this, and if so, what would impact their decision. One mentioned price as the driving factor while another mentioned high functionality - all three emphasising the importance of its design and feel in the hand. Asking about the current design, all users felt the neutral bright design could fit well into their homes as they could see themselves leaving this remote out in the open, blending in well with various interiors. All three agreed that this remote could help them in reducing their screen time if the device would be capable enough to control most of the smart home. In summary, the various parts amounting to the full concept was appreciated by users, highlighted by some quotes from the interview with users (figure 35).

Figure 35. Some quotes recorded during the final test.

6.

Discussion

Research goals

Having been accepted by Pilotfish with my idea for how smart home control could become more inclusive - and with increased usability - it was still my project and thus me setting the goals and deliverables. As a lone developer, it was harder to evaluate how the planning and tasks should be decided upon but with support from Helena and Harm I came up with a plan that was doable - albeit ambitious, thinking there were big social, economical, and possibly even sustainable gains to be had with this concept. My first goal to explore what women required from a tangible smart home device was successful in providing insights in line with the developed vision, and thus also the women target group who appreciated it. The validity of using the vision as a tool for finding a target group, as suggested by Hekkert and Van Dijk, might not be fully suitable. With close and distant friends being asked to partake only if the vision was deemed fitting, it is possible some filled out the form either way just to support the cause. With that said, supporting the development of a product that highlights issues of gender-bias and usability is still good - and something I am proud of being able to facilitate. It is probable though that I have brought some of my own preconceptions into this project, possibly designing a product that is less disconnected from male influence. Even so, I think it is important for designers and humans alike to dare venture outside of their comfort zone to learn from others but also to hasten our shift from the problems of todays society. Surely there is some uncertainty to how well the participating women truly would want to use the developed concept in the end, if it actually would be the preferred option for achieving common smart home tasks instead of using a smartphone. Still, it is likely that the participating women or some other target group like elderly - or those with even bigger resentment of phone use - might appreciate Sally highly for its analog design and use.

Given the limited resources of this project I am pleased with how much relevant data has been collected, aiding development of the user interface. The insights from users, research, and usability guidelines, in combination with my previous experience of designing digital user interfaces resulted in a simple yet capable interface that should be flexible enough for control of many different smart home systems. With the vast difference in various smart home app designs, and different experiences and mental models of users, it is hard to say if the interaction design of Sally is a true winner. But, as the second goal of this project was to develop a tangible device to be more efficient than the Homey app, or smartphone use in general, the better system potential of my device at least provides the prerequisite for being more efficient. During tests, users did take quite much longer to finish tasks, needing more clicks and to get some help, but the usability score was still high with user expressing appreciation for the concept in general. The learning curve was also deemed low by all users which makes me think Sally would truly be more efficient than any combination of smartphone apps for achieving the included tasks.

The last of the three main goals, exploring how a tangible device can provide increased visual, auditory, and tactile satisfaction compared to smartphone use was part technical and part emotional. First, the intended functionalities needed to be added in a way that fits and makes sense to give the users a quick and easy self-explanatory interaction. Second, to

make the experience delightful, very many parameters needed to work together to achieve such an elusive goal. For example, if the enclosure of the product feels a bit cheap, it does not matter how nice the haptic feedback feels when rotating the knob. All of the sub-systems really need to work well together to achieve a gestalt preferred by women that also lives up to the image of how the device should work and feel when being used. As you cannot design a user experience due to its reliance on the user and situation - both of which are fleeting and subjective - the best I could do was to provide for an interaction experience that differed from that of the flat, indistinctive and glossy touch displays of our smartphones. This differentiation towards a more tactile multi-sensory experience I knew, from users and research expressing it, was better for the overall usability but highly likely also for improved delight. Especially knowing that some people, including myself, sometimes dread picking up the smartphone to achieve smart home tasks. I believe that my prototype, the app-free way of interacting with the smart home in a refreshing and effective way proves that I succeeded in delivering an interaction experience plausibly superior to those of smartphones.

Methodology

Given that I was taking on a large project by myself, I felt the need to support my work on some structured method to help me complete relevant tasks for developing the concept from early concept to prototype. Having just learned and worked with the ViP method once, I felt it fitting to further hone my skills of using it in this project - especially given that it is highly suited for developing novel products where it is allowed to use the influence of ones own personality and experiences to help change a given context to the better. All of which while still having my feet planted steadily on the ground so that the concept also could be feasible to produce and appropriate for its users and the smart home domain.

Next, I needed some method to give me the aforementioned structure, which is where the ACD³ felt suitable as I had worked some with it before, wanting to test it further. With its extensive guiding questions across its plethora of different steps, it quickly became quite hard to keep track of everything in a good way - especially when feeling that some steps might not be totally applicable for my project, leading me to spend time doing tasks that in the end could have been skipped. There are some valuable parts of this method but to me, it showed to be too rigid, time-consuming, and with a difficult and confusing nomenclature. Maybe if having profoundly more time to develop a product, within the confines of a structured company, in collaboration with an actual development team, maybe then it could be helpful. Rather, as the overall goal of the project was to develop a delightful experience, Don Norman's methodology Emotional Design proved to be a helpful tool - albeit in a very abstract way. The three levels of emotional design becoming more of a framework for changing my mindset accordingly for work within each level. Hence, the first period of my project was more reflective, looking at the effect and use of the intended product with input from the user survey, diary study, and research. The second behavioural level looking more at usability and interface design with much direct input from users. Lastly, the third visceral level helped me get into the mindset of developing the prototype to be as delightful as

possible. This level helped me to set external input aside for a while to properly focus on developing a good prototype. To me, it was helpful to make this space for myself to not feel overwhelmed by continuously feeling an urge to evaluate with users - rather, I spent my time making the prototype as functional and delightful as possible for users to test at the end of the project. These insights could then be helpful for future developments of the project where more rigorous tests could be performed again.

Vision

Given that this project was not anchored to any company or external stakeholders, it seemed fitting to use the ViP method for this development to create a personal but well-founded vision to guide the project. The vision was not only helpful to guide my own solo work, but also helpful to to attract smart home users for testing and evaluation of the concept. Having completed the project with my goals reached in a good way, and having produced a product that meets the concept drivers of the vision, I think it was a wise choice to use this method. Especially when one is trying to break some new ground, I felt more at ease in my work which saved both time and strain from second-guessing my own work. Much like the ViP method describes itself, it is suitable for designers who can work more freely in their own direction, take responsibility for their actions, and add their own mark of authenticity to the work. This is something I feel my concept delivers as it portrays some of my values while still being designed for the needs of women users. Albeit not all women, I think there is a true desire for a distraction-free product like this.

Having introduced my master thesis work to people during the project, both women and men always responded positively to the idea of reducing our phone use, and to provide a more tactile experience of controlling the smart home. One issue though with using such a strong vision, developed by myself, is the risk of confirmation bias - something my supervisor at Pilotfish hinted at. Working alone in this project has surely made me more subjected to confirmation bias, thus altering the direction of the project. But, at the same time, the vision with its factors shaped a well-founded and thoughtful statement to make the smart home experience better. In my mind, I always took responsibility for the direction chosen; surveys, interviews, and tests constructed accordingly. And to me, this direction was clearly appropriate not only because of the knowledge I've attained through designing the vision, but from talking to the participating women, and many others. Everyone I've talked to, except some old-fashioned men, was in full agreement that an easy and quick interface that does not rely on apps is something desirable and worth developing.

The smart home market and its users

To decrease the risk of me as a man choosing to follow my own subjective and possibly unfounded ideas, it felt valuable to do a diary study with women owning smart home products. This study did gave some valuable data, but as few of the participants wrote down much suggestions or pain points in the diary, the result was mostly a mapping of when and what tasks they completed - and on what device. This was helpful for understanding the use

patterns and how much each device was used but much of this could probably have been found in research papers on smart homes. What data that could have been helpful to collect, was what main activity users were doing for every hour at home. This way, what personal experience goals users had would have been cleared - for example, wanting to relax, enjoy a cozy time in the sofa, etc. With the concept being developed for these pleasant moments, such data would be helpful as arguments for future design decisions.

Given the ambition of the project, the timeframe for collecting data was initiated swiftly by me which might've been a bit stressful for users. It would've been better to introduce users earlier so they could choose more for themselves when to do the diary study for example. This was of course, as often, partly due to lack of finding participants in time. Also, as all users recorded their data digitally, it might have effected the results as needing to have the phone with them to record data could have altered how they would interact with the home. Even so, this possible effect is deemed of minimal importance to the overall validity of the diary study. Given more resources, open or hidden observations of their smart home interaction could have provided more valid results, but, the former also poses its limitations while the latter is both unethical and problematic even if consent for recording their homes would have been given.

What was more valuable though, was that the diary data became a foundation for my interview questions and the discussions had with users. In addition to me knowing more about their daily smart home use, I think it was valuable for the users to also be primed into thinking more about their routines. Hence, the follow-up interviews was very valuable to probe the users further about key aspects of the vision and areas like voice control, wearables, and other aspects that other companies had tried in their interfaces. In the end, the effect stage amounted to a big collection of data which was somewhat hard to concretise. This fact, and that much time was consumed into following the ACD^3 structure closely, made me question how much of this work actually resulted in value for the project.

As I felt time running out, I think the depth of my analysis became limited - given more time, more insights could be had to benefit this or other smart home related projects. But still, 20 requirements was collected at this early stage in the project as a good foundation.

Utility and design guidelines

In the use stage, it was also time for making decisions about what and how the interface would look - something highly influenced by my vision and previous work during a course at TU Delft the preceding semester. During that course, the first idea of the concept came to light, and already then it was conceptualised as a bright handheld device with a knob. Being aware of this, in the development I did explore other options than using a knob for volume and light control, but in the end the knob was still chosen as it proved to be a concept not tested by other smart home remotes. Asking users about their feelings towards a knob, slider or scroll wheel it was not totally clear which was the winner. Some could see a scenario where the knob worked really well, while others felt it could be in the way or

somewhat unintuitive. Knowing that making place for a horizontal slider in the interface was possible if a knob did not work - or if it would look to clumsy - the latter was chosen to have its suitability for the concept be explored more properly in the functional prototype.

Interface design and testing

For both the heuristic evaluation and user tests, it would've been helpful if the digital prototype was developed with more capabilities to reduce errors and dead ends when clicking around more freely as users often do to test things out. Still, as the results of the early heuristic evaluation was as low as 1,1 out of 4 in the every scale, I was pleased with my thorough work to follow usability guidelines so that the user interface at that stage only suffered from cosmetic or minor usability issues that easily could be fixed.

Testing the user interface and evaluating other aspects like the form factor was truly a key moment in the development project as it gave a lot of valuable insights and provided the first true sense of that the concept could be highly appreciated by users. Having pre-selected a few common smart home tasks for the users, it was observed that looking for feedback was not done properly by users - leading to some delays and errors during testing. Even though this impaired the results of the testing, the discussions with users made it clear to me that an interaction with a fully functional device with their own chosen goals would make the interaction much more seamless and fault-free.

Given the small sample size, and variety in results of the usability score, the validity of the user test could be questioned but as it still resulted in the high score of 77,5 - almost 10 points more than the average of 68 - which in combination with the result and praise from the expert tests showed that the chosen interface design was well worth developing further. Ultimately, this first round of tests were successful in gathering useful insights and appreciation for the concept, feeding the next stage of the project.

Delivering a tactile experience

At this point, doing own tests was deemed okay for selecting a way forward for the prototype - for proper development the product would benefit from having various prototypes built. Still, I felt that the insights from diary and test participants was clear enough for making the first iteration of the concept into a functional prototype. Given, the idea of the concept to use dynamic displays, a knob and buttons with relevant feedback systems like audio, haptics and light, the build of a functional prototype that was slim enough to be held in one hand proved challenging - especially when standard Arduino components are bigger than professional components for use in compact consumer products like smartphones. Even so, I managed to build a device that was only slightly bigger than the intended size. Instead of being 130 × 50 × 15 mm, I fit all components in 140 x 60 × 20 mm, a size deemed worthy of being explored by users.

For the final test, the user who appreciated the visual ring feedback of the functional prototype was the kind of reactions is what I was hoping for with my concept. Making it

more delightful to interact with the smart home. The novelty of the concept, by its unique combination of the D-pad, knob and visual feedback seems to interest the users, but it is too early to say how well its appreciated after long-term use of a fully functional prototype. It is a good starting point though as all users clearly expressed a strong will to reduce their screen time - a comfortable and dynamic device being appreciated for its convenience and versatility while still being self-explanatory and easy to use for novice smart home owners.

With the limited time available, and limited Arduino experience, how details of the product could look was not explored in the project. Still, most user requirements were met in providing a slender, bright, minimal and usable remote. In the end, I am proud of how I managed to realise my personal goal of developing a high-fidelity prototype that was also appreciated for its design and functionality by users, concluding this project with a functional prototype and plentiful of insights to aid in future development of the project. Such developments should also explore how the device can provide a more sustainable interaction with our smart home - one of the early ideas for this concept was to be just that, more environmentally friendly than using smartphones by use of modern energy-efficient technology. And maybe more importantly, providing an interaction for increased well-being, not one that creates mental distress or confusion.

Concluding remarks

This project has been both challenging and fun, leading me to work with new methods, gain new knowledge of the smart home domain, and to trust myself in my decisions. With the support and benefit from being in the office of Pilotfish in Amsterdam, I was able to perform an extensive user study while also completing my personal goals of developing a good user interface and prototype. Having worked with only women as survey, diary, and test participants, it is clear to me that there are many insights that are not found out by the design industry in general. Also, even though I tried putting my own perspective and experiences as a man aside, I think that valuable insights still could have been missed during the project. I am certain though that this experience have been valuable for me as a designer to learn to expand my perspective for future projects, and hopefully, it can inspire someone else to push the boundaries of what can be done to reduce gender-bias and improve the usability of products overall for all its users.

Having only scratched the surface in exploring what women of the target group, and other potential groups like elderly women require from a good interface, it is clear to me that there is a substantial appreciation for the developed concept and its potential of making the smart home interaction better for everyone. The novel interaction flow and combination of components gave birth to a concept unlike no other on the market; still being familiar to users. My hope is that the Sally concept can bring some novelty and excitement to smart home users with the quick, easy, and delightful interaction it was designed for.

7.

Conclusion

This project has proven that for women who want to streamline their smart home interaction while reducing smartphone use, Sally was easier, quicker and more delightful to use. This chapter answers the research questions, followed by a checklist to see if the concept aligns with the updated good design guidelines, and, suggestions for future work.

7.1 Answers to research questions

This project collected valuable insights on what women require from a tangible device to make it a preferred option for achieving common smart home tasks. Women emphasised the importance of having both manual and automatic smart home interactions be quick and easy. And, if a tangible device is to be preferred, it needs to have a high capability similar to what can be done on smartphones.

Having evaluated how common smart home apps operate, a novel interface design was proposed to allow for control of heterogeneous connected devices with an emphasis on control of lights, streaming, comfort, and automations. By use of tactile buttons, a knob, and dynamic displays, the remote concept was evaluated with users for common smart home tasks, showing moderately better results than what could be achieved on a smartphone. If accounting for the users expressed mental distress of being forced to use smartphones - and the notion that using a smartphone sets of a chain-reaction of use - the proposed concept is considerably more efficient.

Lastly, the exploration of how to embody the interface design in a delightful way to improve user experiences showed that the novel combination of a D-pad, knob, and circular light feedback can spark positive reactions from women users. Having developed a product that fits comfortably in women's hands, the concept was appreciated by users for its minimal, bright aesthetics, and how its use promote more serene, disconnected and pleasurable moments in the smart home. Ultimately, the development of the Sally concept for modern women, conscious of their well-being and the environment, has proven successful. The results of the project a good starting point for continued development of the concept to benefit millions of smart home inhabitants while highlighting issues of gender-bias.

7.2 Sustainability and the good design guidelines

Regarding the environmental impacts of this concept, it is hard to tell how much the additional CO^2 emissions for manufacturing the proposed design can be offset by the reduction of smartphone use (which require a lot of energy through its bright displays and heavy computing). But, as the concept is designed to make use of display technology with lower energy use than those currently in smartphones, it is reasonable to think that manufacturing and long-term use of the smart home remote would be less taxing on the environment compared to our current smartphone-heavy interaction. Additionally and importantly, the concept would promote well-being for smart home users as they would not need to rely on their smartphones as much. Also, being designed to be inclusive and intuitive, the remote makes the benefits of smart homes accessible to more than just tech-savvy men. Hence, the concept in its current state has been evaluated against the updated good design guidelines by Jo Barnard.

1. *Good design has a reason to exist*
2. *Good design is inclusive*
3. *Good design is built on honesty*
4. *Good design is thorough through to end-of-life*
5. *Good design is designed for appropriate lifespan*
6. *Good design is intuitive*
7. *Good design is people and planet-centred*
8. *Good design encourages positive behaviour change*
9. *Good design is beautiful*
10. *Good design is considered down to the last detail*

The concept has a good reason to exist, is inclusive and built on honesty when pushing for change in this male-dominated industry. Number 4 and 5 is not yet accomplished but the concept have been developed to comply with these in the future - especially as the concept has been developed to create an emotional attachment between the product and user, meaning it provides a chance of prolonging the user-product relationship. This concept is deemed intuitive, people and planet-centred, and, that it also encourages positive behaviour change by reducing our dependancy on smartphones. Given the user feedback in the final test, the concept is also deemed beautiful. Lastly, given the extensive work to provide a novel but still familiar interaction concept that works for controlling most of the smart home, many aspects of the design has been considered in detail. Ultimately, having reviewed the 10 guidelines, the concept and its intended use could be deemed 'good design' for the 21st century.

7.3 Future work

As the focus for this project has not been on fully developing the final detailed look of the product, more refined explorations of semantics and product feel is needed. Primarily, the concept needs to be developed as a fully functional prototype to be tested in a real smart home setting over a longer period of time. For this, additional work on how users can interact with the remote will further improve the usability. Given that all the good design boxes are not yet checked, exploring how the concept can be designed for an appropriate lifespan and circularity is highly recommended.

Then, if successful, refinements to the look and feel of the product can be performed. Additionally, exploring how different auditory, visual, and sensory feedback can be used to enhance the experience is also needed to better differentiate the product from the bland interaction of smartphones. Lastly, how the remote is to be installed, charged, and have settings adjusted - as part of an existing smart home app or something else - needs to be explored further to make sure it fits well with the fully integrated future of smart homes arriving with the coming release of Matter.

8.

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9.

Appendices

Learnings from culture survey (Delft course)

Summary of results and survey

- Participants: Distributed age group and somewhat equal gender division. Most have smart lights and speakers, controlled by apps generally. Many also have some kind of button. Common problems are the wish to not use apps and having connection issues or voice command not working (women). In one third of shared homes, men was mostly in control (the other two thirds had a somewhat equal split of control).
- Most important to control: Lights and speakers equally important. Women valued safety highly, as well as heating and ventilation. Only men valued control of smart assistants.
- Most important daily activites: Controlling lights equally important, selecting sound media most important for women but also important for men. More than twice as many women want to see the weather and control the temperature. Selecting a specific song is also quite important. Setting an alarm is also wanted.
- Important for control panel: Women want good looks and flexibility to bring the controls with them at home (men preferred fixed more and appreciated the feel of buttons more). Both genders value ease of use and few clicks but women so much more. Feedback of action, state, and ease of use in the dark is important for many.
- Preferred qualities: Both genders prefer an interface that is simple, minimal, smooth, rubbery, rounded, no color. Women prefer a bright product while men were split between dark and bright.
- Moments to automate: routines for morning, evening, movie night, location and time adaptation for light and heat automation, walking around at night to bathroom being lit dimly, control products from afar
- Noise: Need to cancel neighbours or construction noise by use of speakers/curtains - or to mask it by playing rain etc.
- Comments: Multiple comments on making it suitable for elders is important. Voice control for women is lacking due to not designed for that.

Interface learnings from culture survet

- What to control: Lights, speakers, safety[w], heating[w], ventilation[w], alarm clock
- Tasks: Lights (on/off/adjust), Sounds (on/off/media/select song), Temperature (on/off/adjust)[w], Review Weather[w], Alarm (on/off/adjust)
- Usability: Ease of use and few clicks most important for women (and men)
- Usability: Proper feedback and tactile recognition very important
- Appearance: Bright[w], good aestechics[w], good tactility[m]
- Appearance: Minimal, Simple, Smooth, Rubbery, Rounded, No Color

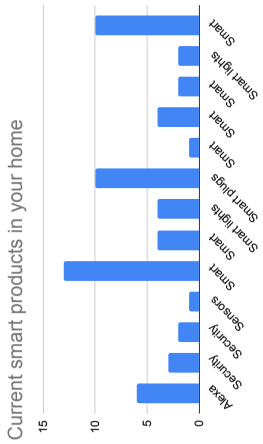
Summary of survey results

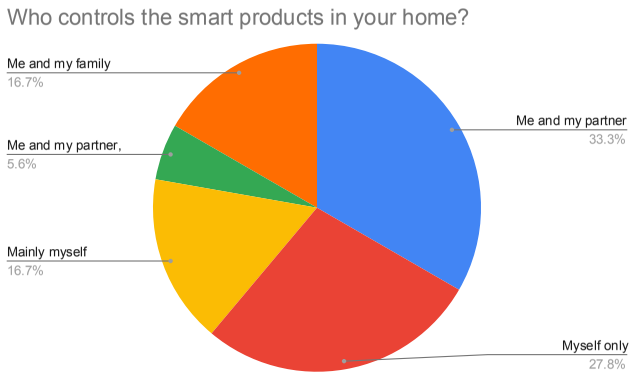
Participant demographics

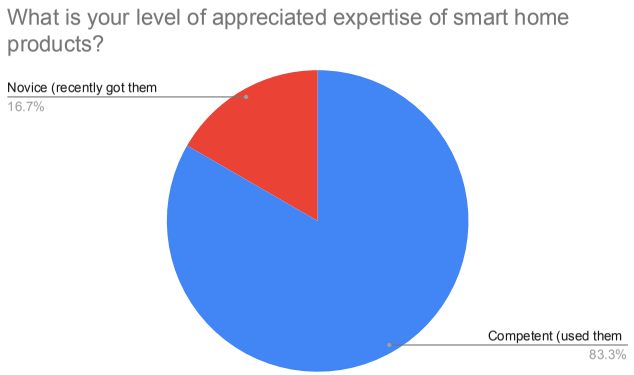
- 22 participants (half from a private Fb reachout, half from a post in the groups "Swedes in Amsterdam" and "Expats in Amsterdam")
- 80% of participants have smart products (20% want to have them)
- Millenials mainly, generation X also many. Half between 25-34 years, 1/5 between 55-64y (1/10 18-24y, 1/10 35-54y, 1/10 45-54y)
- Living arrangements and who is in control
  - 1/3 is living alone, mainly controlling SHs themselves
  - 1/3 lives with a partner, sharing control of the SH
  - 1/3 living in other constellations like a family, mainly the two partners in control
- Living type and size
  - 4/5 living in apartment, most in size 50-100 sqm (2/3 in 2-3, 1/3 in 4-5, 1/10 in 1 room)
  - 1/5 living in houses, all in 100+ sqm (all with 4+ rooms)
- Womens buying decision influence on smart home products
  - Almost 1/2 mainly or fully decides themselves
  - 1/4 decides with partner equally
  - 1/4 with partners or parents mainly deciding

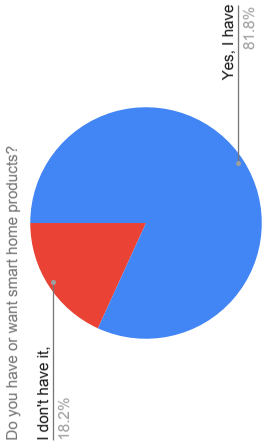
Smart home demography and use

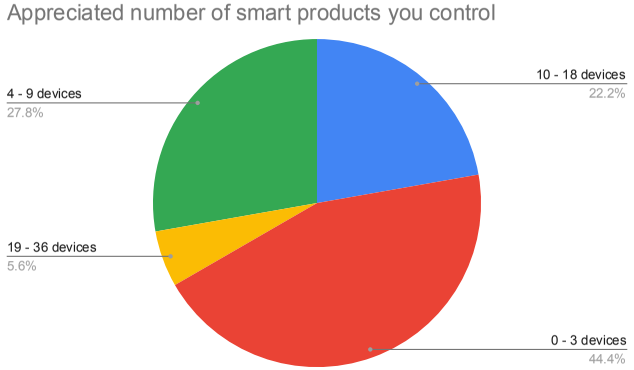
- Smart product division as follows:
  - Majority had a smart TV
  - Majority had some kind of smart lights (plugs or hue/ikea/similar)
  - Half had smart speakers
  - A quarter had home assistants
  - A few had security systems or thermostats
- Devices used for control:
  - Majority used a smartphone
  - Half used tangible devices
  - A quarter relied on automations
  - A quarter used voice control
  - A few relied on sensors
- Half of participants have 0-3 devices, one quarter having 4-9, and one quarter having 10-18
- Majority deem themselves as competent users and interacts with the smart home many times a day
- Majority concerned about their smartphone use (various reasons: putting phone away in general, some more at night, some do not want the phone in the bedroom at night)
- Two comments from participants focused mainly on reliability issues; devices not connecting properly, starting slowly, etc.

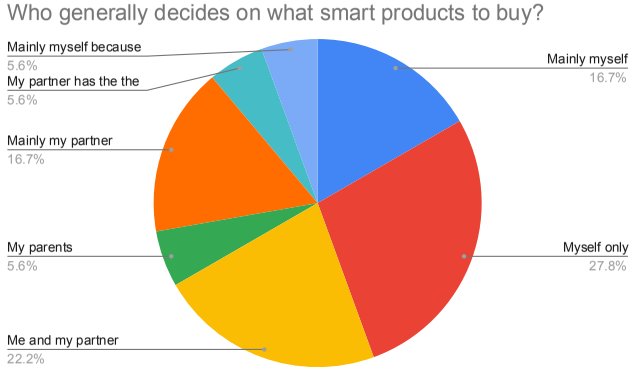

Current smart products in your home
Smart
Smart lights
Smart
Smart
Smart
Smart plugs
Smart lights
Smart
Smart
Sensors
Security
Security
Alexa
15
10
5
0

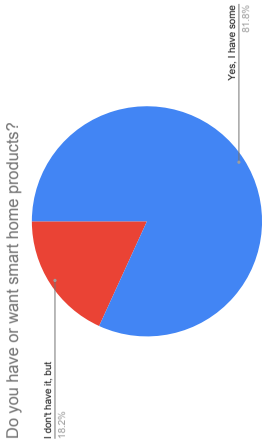

Who controls the smart products in your home?
Me and my family
16.7%
Me and my partner
33.3%
Me and my partner,
5.6%
Mainly myself
16.7%
Myself only
27.8%

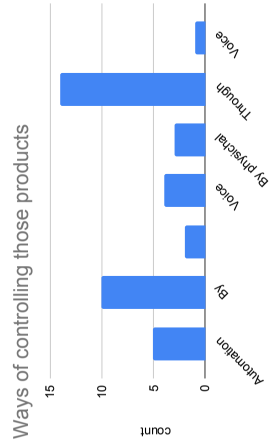

What is your level of appreciated expertise of smart home products?
Novice (recently got them
16.7%
Competent (used them
83.3%

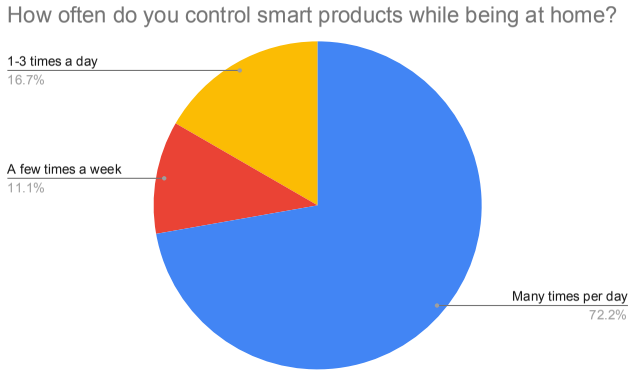

Do you have or want smart home products?
Yes, I have
81.8%
I don't have it,
18.2%

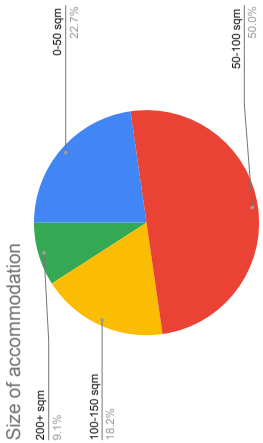

Appreciated number of smart products you control
10 - 18 devices
22.2%
4 - 9 devices
27.8%
19 - 36 devices
5.6%
0 - 3 devices
44.4%

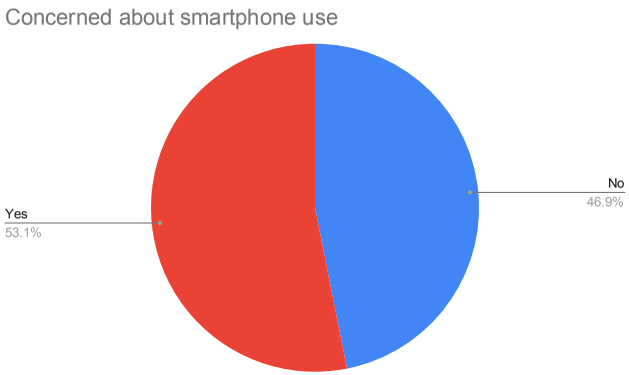

Who generally decides on what smart products to buy?
Mainly myself because
5.6%
Mainly myself
16.7%
My partner has the the
5.6%
Mainly my partner
16.7%
My parents
5.6%
Myself only
27.8%
Me and my partner
22.2%

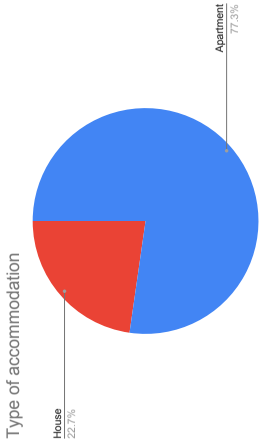

Do you have or want smart home products?
Yes, I have some
81.8%
I don't have it, but
16.2%

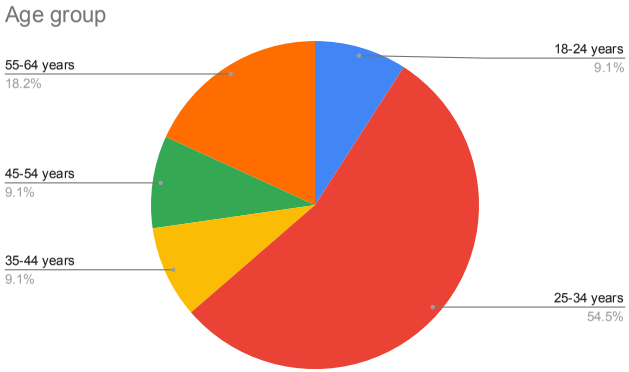

Ways of controlling those products
Voice
Through
by physical
Voice
by
Automation
15
10
5
0
count

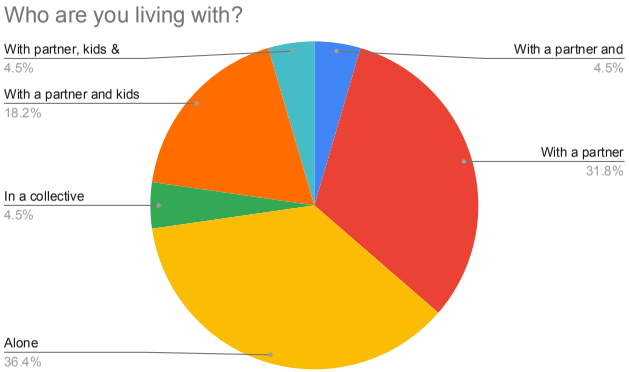

How often do you control smart products while being at home?
1-3 times a day
16.7%
A few times a week
11.1%
Many times per day
72.2%

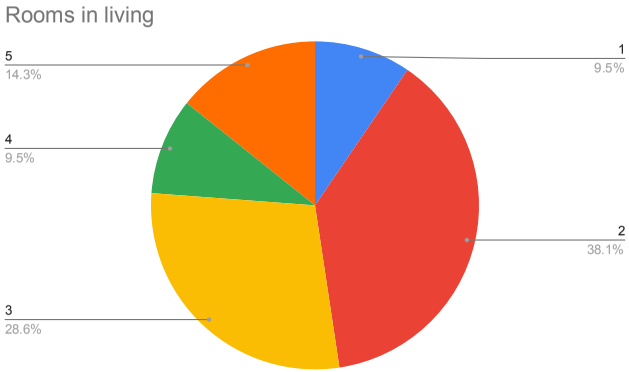

Size of accommodation
0-50 sqm
22.7%
50-100 sqm
50.0%
200+ sqm
9.1%
100-150 sqm
18.2%


Concerned about smartphone use
No
46.9%
Yes
53.1%


Type of accommodation
Apartment
77.3%
House
22.7%


Age group
18-24 years
9.1%
55-64 years
18.2%
45-54 years
9.1%
35-44 years
9.1%
25-34 years
54.5%


Who are you living with?
With partner, kids &
4.5%
With a partner and
4.5%
With a partner and kids
18.2%
With a partner
31.8%
In a collective
4.5%
Alone
36.4%


Rooms in living
5
14.3%
1
9.5%
4
9.5%
2
38.1%
3
28.6%

Guide: Diary study

Development of an inclusive and tactile smart home remote

Goal of diary study

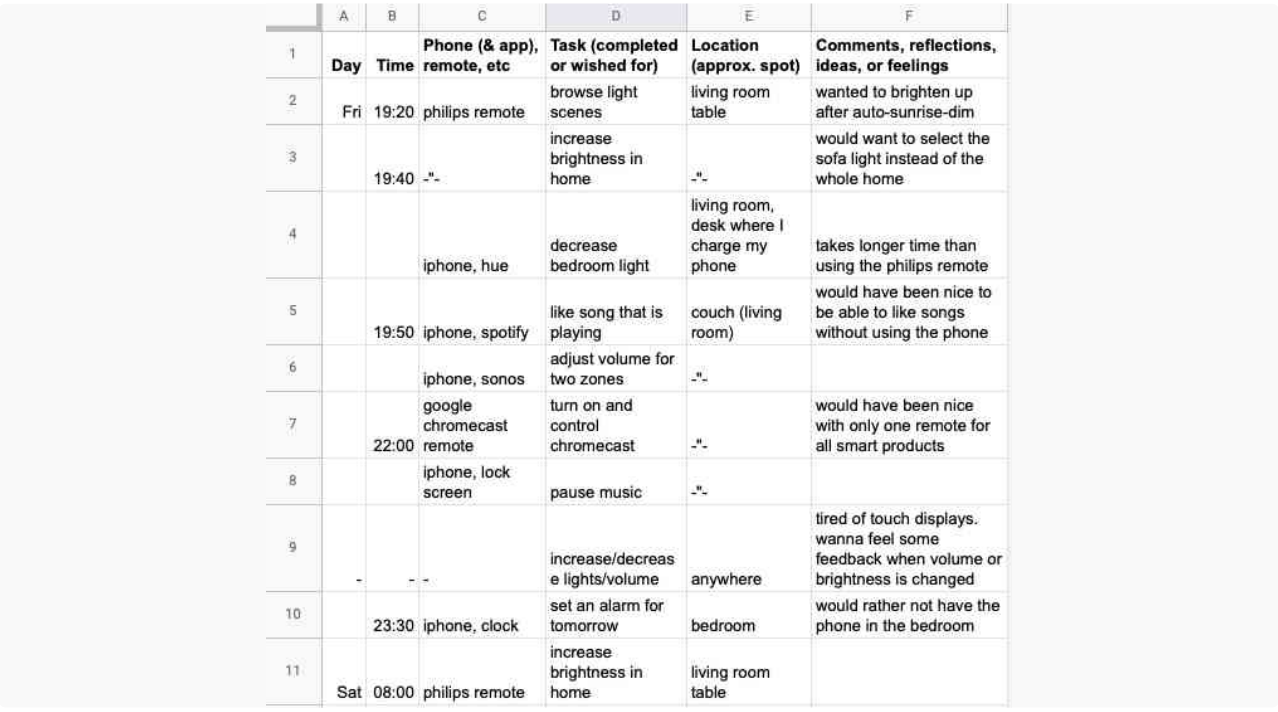
Understand how smart homes are used by women right now, pain points, and possibilities for improvements (like being able to control other things like alarm clocks from a remote etc).

How the study is done

1. Intro meeting: I present the project, the guide, and answer any of your questions [≈15 min]
2. Diary: You fill out the smart home diary over 2-4 days (goal is to get data over a few 24h cycles)
3. You send me the diary digitally (or as photos of your handwritten diary), and a consent form allowing me to store the results during this project (form will be provided)
4. Follow-up interview discussing the results, and what you might want (or do not want) from a future smart home remote [≈30 min]

How to write the diary

- Note down all smart home interactions (or those you remember to do), preferably digitally on your phone (or on your computer if needed). A template will be provided. It is also okay if you'd rather write the table down on paper, or print it out.
- Refer to this example image for how the diary can be filled out (with some ideas and feelings written down as well)
- Okay to write in English or Swedish



	A	B	C	D	E	F
1	**Day**	**Time**	**Phone (& app), remote, etc**	**Task (completed or wished for)**	**Location (approx. spot)**	**Comments, reflections, ideas, or feelings**
2	Fri	19:20	philips remote	browse light scenes	living room table	wanted to brighten up after auto-sunrise-dim
3		19:40	-"-	increase brightness in home	-"-	would want to select the sofa light instead of the whole home
4			iphone, hue	decrease bedroom light	living room, desk where I charge my phone	takes longer time than using the philips remote
5		19:50	iphone, spotify	like song that is playing	couch (living room)	would have been nice to be able to like songs without using the phone
6			iphone, sonos	adjust volume for two zones	-"-	
7		22:00	google chromecast remote	turn on and control chromecast	-"-	would have been nice with only one remote for all smart products
8			iphone, lock screen	pause music	-"-	
9	-	-	-	increase/decrease lights/volume	anywhere	tired of touch displays. wanna feel some feedback when volume or brightness is changed
10		23:30	iphone, clock	set an alarm for tomorrow	bedroom	would rather not have the phone in the bedroom
11	Sat	08:00	philips remote	increase brightness in home	living room table	

Good to remember when doing the diary

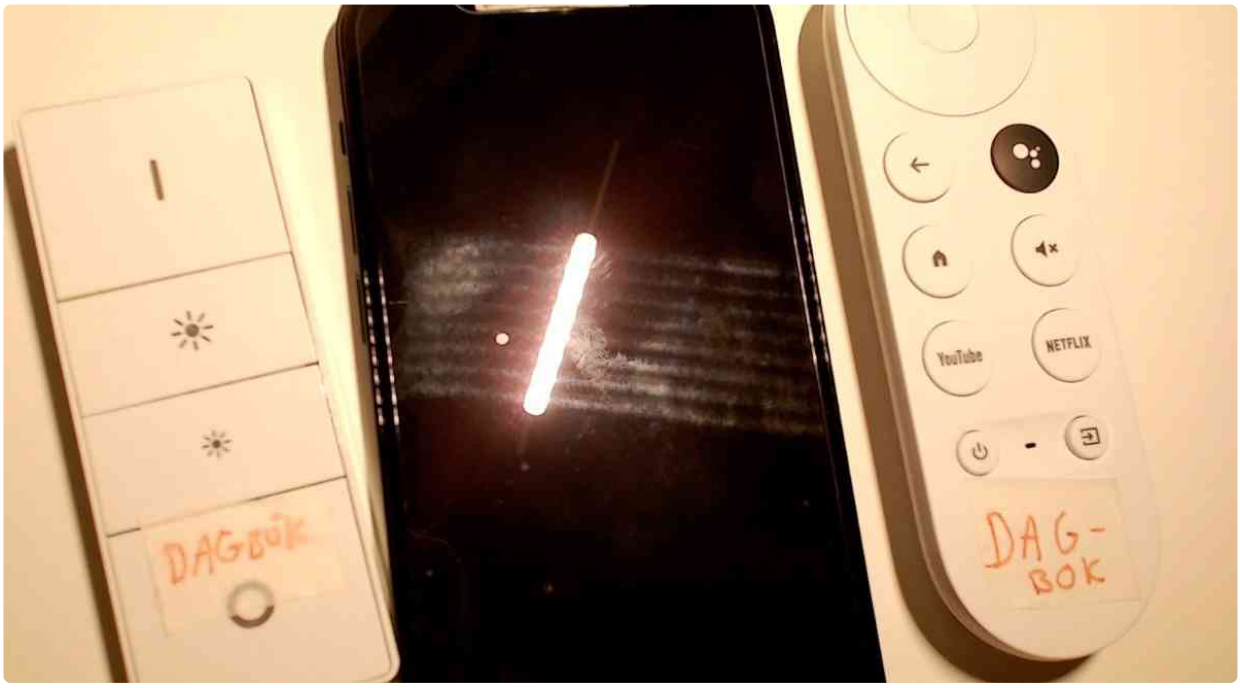
1. This study is not to evaluate what you as an individual does, it is t understand women's smart home use in general - none of your smart home interactions or reflections are wrong.
2. Time entry does not have to be exact. A rough estimate is good enough.
3. Any things a partner or friend controls in the smart home is not to be included (things controlled when not being at home) - this is about *your* experience and interaction with the smart home.
4. You do not need to add something to the comment field if you do not feel like it...
5. ... but it is very valuable if you also write down general ideas, reflections, or comments (things not directly connected to something you just controlled). Below are some inspiration.
    - My statement: *Interacting* with a smart home should be *easy*, *quick,* and *delightful;* just like the experience of actual smart products are.
    - Are some qualities of products more desirable than others? For example, "I like the button feel of my Philips remote", or "a smartphone does not allow me to control without looking".
6. The more diary inputs I get the better, but don't stress that you have to remember to enter *everything* in. As long as I get a general sense of how you interact with the smart home that is great.
7. Also, if you have apps/tools/products you use daily like the alarm clock app, please write them down if you would like to control them in another way as part of the smart home.
8. Tip: Put some tape with the text "diary" or something on your smartphone, remotes, etc (all places you control the smart home), to help you rememer to write in the diary.

If there are any questions, don't hesitate to contact me!

Simon Dybeck, +46709-241531, simon@battredesign.se

Koninginneweg 183-2, 1075CP, Amsterdam

At any point during the study you can decide to quit and/or ask for your data to be removed.



Appendix 4: Diary study interview

Making use of smart home products more inclusive and app-free

This interview is about how you live and use smart homes; the activities you often do and want to achieve
Split in 5 sections
it is to get an understanding of what is important to you

A. Smart home meaning & use

1. Why do you have SH products?
   Does it improve your life? If so, how?

2. Is there any particular moments during the day that SH brings positive feelings?
   Like when eating or spending time with family? Or waking up by "sunrise"? What feelings do you get?

3. Is there any SH system, product or task, that is extra meaningful to you?
   What feelings do you get?

4. Is the positive feelings you described above, mirrored in your interaction with a smartphon or a remote?
   Do you think the feeling of controlling the system corresponds with what the feeling the system provides?

Many tasks can be automated, while some tasks are more manual as they are activity-based like turning down the lights for a cozy dinner

5. What kind of control do you prefer? Always automatic, or always manual in general?

   Mark only one oval.

	1	2	3	4	5	
Fully automatic	◯	◯	◯	◯	◯	Fully manual

6. Elaborate. Benefits and drawbacks of auto/manual?
   Elaborate. Benefits and drawbacks?

7. Looking at the task of installing or setting up devices (called "digital housekeeping")? Is it something you like to do?
   Why is that?

   Mark only one oval.

   - ◯ Yes, I like it
   - ◯ It is okay, but try to avoid it
   - ◯ No, really hate it!

8. Comment on "digital housekeeping"

9. 5. Do you feel confident in your abilities to control the smart home? Why? Why not? How does this impact you?
   What could alleviate this feeling? Do you know how to improve the situation?

10. EDIT: (if not living alone): Do you and your partner control the home with the same device sometimes? which? why?
    DO NOT ASK: Jasmine

B. Phone placement

11. EDIT: You said X about phone use concerns? Why is that?
    Sara: Yes, want to remove bedroom, Cecilia: yes, no phone in bedroom, Amanda: fine now, done changes in past, Jasmine: yes, away sometimes. Felicia: yes, away sometimes

12. If leaving it somehwere, do you generally put it in the same place? where? why?

13. Where would you want to place it? Why?

14. Seems like you control your home from many different places, is this an issue if not having the phone with you?

15. How does it feel to need different apps for controlling your smart home? Is there any othe way you'd prefer? why?

C. Device needs

Device and remote used interchangeably

16. Could a remote be an option to using the smartphone for controlling your home? What would it need for you to choose it over a phone?
    In terms of ease of use, speed, pleasantness?

17. What activities would you want to control with such a remote?

    Tick all that apply.

    - ☐ Controlling music to play
    - ☐ Adjusting lights (brightness and color)
    - ☐ Changing home temperature etc
    - ☐ Choosing what to watch on a Smart TV
    - ☐ Setting the alarm
    - ☐ Change security alarm state
    - ☐ Talk to smart assistant
    - ☐ Other:

18. Comments activites

19. What do you feel if I say the device interaction should be characterised by...
    Any word that stands out to you in a negative or positive way?

20. What do you feel if I say the device should be...
    Any word that stands out to you in a negative or positive way?

21. If such a device would exist, where would you want it?

    Mark only one oval.

    - ◯ Fixed to the wall
    - ◯ Mounted to the wall but removable to bring around the home
    - ◯ Only as a remote
    - ◯ Other:

22. Do you think there is a risk that the remote would not be close to you when needed? Why How to prevent it?

23. Do you think you would bring both your phone and the device around? How could this be prevented?

D. Remote comparisons

So try and think of yourself at home, wanting to control your smart home, and you have to use any of the following devices meant to control the whole smart home. How would you feel in regards to ease of use, quickness, and pleasantness?

would you want to use it?

Read top info about the device first. Then

Sevenhugs

24. SEVENHUGS: easy, quick, pleasant, choose?

Flic Twist

25. FLIC: easy, quick, pleasant, choose?

Harmony Express

26. HARMONY: easy, quick, pleasant, choose?

Homey app

27. HOMEY: easy, quick, pleasant, choose?

E. Final questions

28. Do you use voice control? What is your opinion about it?
    for example something you do on your phone now that you really want it to do. probe

29. Would a wearable like an apple watch be a good option? why? why not?
    for example something you do on your phone now that you really want it to do. probe

30. Do you work from home?
    for example something you do on your phone now that you really want it to do. probe

    Mark only one oval.

    - ◯ Only home
    - ◯ Mostly home
    - ◯ 50/50
    - ◯ Mostly office or similar
    - ◯ Only office or similar

31. What kind of functionality could you not live without in a remote?
    for example something you do on your phone now that you really want it to do. probe

32. When writing, music or similar on/off, do you also choose what to play? how?
    for example something you do on your phone now that you really want it to do. probe

33. CECILIA Use/Task Diary Results
    Mostly turning on and off devices... Only changing music ONCE. Is on/off functionality enough..? Selecting song?

34. SARA Use/Task Diary Results
    Many various light groups on/off, is each lamp separate? Should one be able to choose a specific lamp? How do you choose the specific media? Is it important to do without to be able to remove the phone?

35. FELICIA Use/Task Diary Results
    Searching for things to play.. is it important that this is quick to leave the phone behind? Showing video door on a remote important? If Apple TV and iPhone could be replaced by one remote, wha is important?

36. JASMINE Use/Task Diary Results
    app fails sometimes, how do you feel about reliability on phone vs remote? important factor? Is the ikea remote mounted? can you remove? any thoughts in its placement? How do you like the ikea remote? No tv remote for streaming? why?

37. Any other thoughts or comments regarding SH?

Appendix 5: Planning of multi-testing

Goal

Interaction flow Usability

Evaluate the overall usability of the interface concept, and the coherence of interactions with lights, audio and video. Compare clicks, time, effectiveness with the measured system potential, and the results of previous ACD course results.

Ergonomics and physichal usability

Evaluate how the proposed concept feels to hold, interact with, and to pick up. Exploring various button shapes will also be accomplshed to aid detailed design.

- Size for holding and picking up comfortably
- button shape

Device appeal (to aid interaction)

- Which of the varying concept gestalts are prefered by diary participants?

Baseline system potential of use for future comparison (metrics comparison)

Setup

- **iPhone MINI? digital prototype with cover**
  - Print cover for my phone MOVE INTERFACE TO RIGHT SIDE FOR EASIER RESCK FOR RIGHT HANDED PPL
  - Use useberry now? Check release notes and my email with them before (can it allow for swiping of knob?!)
- **Size mockup**
  - plastic with knob attached
  - paint it white? NO, K-I-S-S
  - paint button names
- **Button components**
  - Print grids of 3x4 to fit on mockup in different styles to also ask about aestethics (put them on device to show how it could look). 10x10 with 2 mm margin
- **Comparisons**
  - Which of the varying concept gestalts are prefered by diary participants?

tests to do - USE AS TEMPLATE FOR INTERVIEW QUESTIONS (30-45 min)

0 - Intro, explain, let them feel the device, consent (10 min)

1 - Usability test digital device (15 min)

- 3 tasks according to Function tables

- Say when stuff happens (play music, turn on light, play netflix, from my phone etc)
- ~~SEQ in between. MAYBE SKIP TO KEEP USEBERRY SIMPLE. Rather ask which task they thought was easiest, and hardest.~~
- SUS in end

Tasks to perform

TV tasks (2)

1. Play 'Our Planet' on Netflix on the Bedroom TV
2. Change to Seinfeld and show Swedish subtitles

Light tasks (3)

1. Turn on the Dimmed scene in the living room
2. Dim the Sofa light in the living room, then change its color
3. Turn on bedroom, then dim lights in bedroom

Music tasks (2)

1. Play your recent Earth, Wind & Fire playlist on Spotify. Select the Kitchen speaker.
2. Increase the volume and like the current song

Tasks for printing
TV tasks · Play 'Our Planet' on Netflix on the Bedroom TV

2 - Interact with device out of hand (5 min)

- Interact with device when it is on table
  - How does it feel to make a simple volume adjustment? (sturdy, quick, easy, why?)
  - Try and select lights, a room, and then rotate the knob to turn down brightness
- Interact with device when it is on wall (hold on wall)
- How does it feel to rotate the knob when the device is laying down/on the wall? Is there a difference? Do you see any possible issues that oculd arise?
- NOTE: Are they using one finger or two-fingers? (which fingers, probe)

3 - Comfort of handling the device (10 min)

- Picking up ease
- Holding comfort
  - How does the thickness feel?
  - How does the length feel?
- Reach while holding device
  - Imagine clicking on the directional pad, then reach the back button and press it. How does that feel?(can the knob be accidentaly turned?)

- How does it feel to rotate the knob when holding it? Is there a difference from when you did not hold the device?
- Placement of knob/d-pad
  - Is the reach okay where the knob is now for clicking around? Or do you prefer it be further up or down?
  - *Ask about* knob shape, height, width, etc
- Optional shape and slider
  - Discuss the othe type of knob shape
  - test with the slider
  - ~~test with the scroll~~

4 - Testing button shapes (5 min)

- Which type of button feels most recognisable to you without looking? (ask to try and find different buttons, like lower left, middle or upper left)
- Which type of buttons design do you think look best if used for a remote?

5 - Comparison of devices (10 min)

- *bring out the other devices, discuss*
- Any of these devices that feel delightful in some way? What do you prefer? (Discuss products)
- Which feel of buttons and material is more enjoyable?

↑ Appendix X: Planning of multi-testing

Tasks for printing

TV tasks

1. **Play 'Our Planet' on Netflix on the Bedroom TV**

2. **Change to Seinfeld and show Swedish subtitles**

Light tasks

1. **Turn on the Dimmed scene in the living room**

2. **Dim the Sofa light in the living room, then change its color**

3. **Turn on bedroom, then dim lights in bedroom**

Music tasks

1. **Play your recent Earth, Wind & Fire playlist on Spotify. Select the Kitchen speaker**

2. **Increase the volume and like the current song**

ViP - Smart home device

1. Background and domain

Products for controlling the smart home (Horizon: next 2 years)

Smart products are meant to improve our daily lives at home by providing technology that can increase well-beling and make daily tasks more convenient. These kinds of products are increasingly adopted by different user groups, but tech-interested men are still the main target market for the industry. This gender bias is not only prevalent in the smart home industry but a huge issue in society in general. This skewed perspective on what smart homes should be, for whom, and how it should be controlled is probably the main reason why adoption rates have missed projections. After more than 10 years of rapid growth, there are only 33% of homes in Europe that have any smart products. Often users and non-users state lack of usability and privacy concerns are important factors that the industry still have not learnt to deal with. With most smart homes being controlled from different apps, users long for a more seamless smart home experience - promised to be provided by the Matter protocol in 2022. This change in the smart home market will be heavily shaped by trends and developments in society where hazardous smartphone use and out-of-hours work communication is sought to be reduced. How, when, and where we control the smart products depend on how developers meet the increasing demands for intuitive, inclusive, and healthy interaction experiences.

2 & 3. Context

The context is built around three main clusters based 56 factors, all with a well-dispersed division between the more fluxating types trends and developments, and the more stable; states and principles. The collective image can be regarded as well-founded due to the majority of sourceable factors, painting a relatively certain picture of the current state of the smart home market, smartphone use, and gender bias. Refer to Appendix 1 for the full list of factors.

Smart home adoption is slow due to misguided efforts

The smart home market have been growing quickly the last decade since the release of Nest and Philips Hue in 2012, but in recent years projections have not been met; one of the main issues being that products and services have been consistently designed by, and for, men. Still only at a 33% market penetration in EU, hese early adopters are generally tech-savvy men. Even though the home is a place for everyone, the industry have failed to adress half of the population - often opting for more high-tech solutions like feature-rich apps and voice control - the former not very suited for new users, and the latter proved to work less well for female voices.

- *Smart home market adoption rate has slowed down*
  Only at 33% market penetration now, compared to the projection of 43%
- *Smart homes have been designed by and for tech-savvy men*
  Leading to the market being stuck with early adopters as their main user group

Interacting with smart homes is complex

As a possible reaction to the slowing adoption rates, the Matter protocol was presented in 2019 as a framework to let all smart home products work seamlessly together. In its absence, after multiple delays, smart homes are generally controlled by use of various apps making the smart home experience daunting and demanding for all users who are not experts, setting up their homes with nifty automations and special solutions. For many years, dutch company Homey have provided a smart home hub to integrate all systems for control in only one app; their service aiming to be intuitive and simple to use but far from being widely adopted. Although there is an increase in possibilties for automation of the smart home, activity-based tasks like putting on music when cooking, or dimming the lights for a more cozy vibe at dinner, still require manual control.

- *Current smart home use lacks proper integration between systems, leading to a more daunting and demanding experience for new and experiences users.*
- *The much-delayed smart home Matter protocol aims to integrate all systems for a more semless experience*
- *Dutch company Homey already provides a seamless solution, albeit only usable with an app.*
- *Activity-based interaction tasks are not easily automated.*

The right to disconnect: Reducing screen time for well-being

While the industry has locked their gaze on smartphone apps being the best interface for controlling your smart home, most people feel a need to reduce their scree time as excessive use impedes our mental and physichal well-being. As most services and communcation is done through smartphones, the obligations to reply to work-related issues and the frequent disctractions from social media have increased mental distress - especially among young girls. With an increased awareness of the health issues related to smartphone use - and privacy concerns from being connected all the time - people are opting more for times of 'digital detox', something new legislations to ban out-of-hours calls and emails from the boss across EU. These developments improve the chances for users to reduce their screen time by putting the phone away when coming home from work.

- *Excessive smartphone use is a health hazard*
- *Majority of people feel a need to reduce their screen time*
- *Increasing number of countries legislate to ban out-of-hours calls and emails from work*

4. Statement

Interacting with a smart home should be *easy*, *quick,* and *delightful;* just like the experience of actual smart products are.

5. Interaction

The interaction with the product should be characterised by 'simplicity', 'delight', 'confidence', 'serenity', and 'companionship'.

6. Product qualities

The product should be 'quick', 'self-explanatory', 'enjoyable', 'familiar', 'tactile', 'dynamic', and 'trustworthy'.

7. Concept

'The smart home companion' (working title) makes it easy for new or experienced users to control all smart home systems at the tips of their fingers. Its simplicity, familiarity and self-explanatory nature brings confidence to users, creating a bond of trust between the smart home and its inhabitants.

Instead of dreading tedious and distracting smartphone use, the tactile remote makes controlling the smart home quick and enjoyable; the pleasant *feel* of every interaction enhancing the users experience of the smart home. Its convenient size making it easy to use with one hand.

Designing for women - who are often overlooked - is not only ethical but can bring a much needed fresh perspective to benefit all users; revitalising the smart home market to increase its adoption rate, equality, and usability. This way smart homes can finally work in better symbiosis with inhabitants to provide a serene and delightful experience worth longing to.

One device for anyone to control the smart home in an easy, quick, and delightful way.

Appendix 1: ViP Factors

1. Mind over Tech just released a card deck filled with 50 bite-sized experiments to disrupt your unhealthy digital habits in order to boost your health and well-being, improve creativity as well as increase productivity. (*The Digital Habit Lab · Mind over Tech*, n.d.) (T)
2. Statistics from 2021 say we spend almost 5 hours per day on our smartphones - a new record high. (Murray, 2022) (D)
3. Right to disconnect: A growing number of countries ban out-of-hours calls and emails from the boss , EU currently working on legisleation to support widespread adoption. (Hughes, 2022) (D)
4. Less is more: minimalistic design is popular for its calming and utilitarian esthetics, combined with users concerns for the environment. (*10 Reasons Why Minimalism Is Trending Worldwide*, 2020) (D)
5. Simplicity is a universally appraised for any human-product interaction. (alison@uxmag.com, 2020) (P)
6. Interaction and experience are fully intermingled (the latter only in the mind). (Hekkert & Van, 2016) (P)
7. Most people experience fear of failure to some extent. (Brooks, 2022) (P)
8. Multisensory input improves efficiency and user experience. Visual and tactile for example. (P)
9. To feel calm and at ease, basic needs of being in control and to feel safe are fundamental. (Kanushkina, 2020) (P)
10. Emotional attachment fosters meaningful (product) relationships, leading to product longevity. (C.A.Bakker@tudelft.nl, 2016) (P)
11. Women have smaller hands than men. (Frothingham, 2019) (P)
12. Women value other things than men. (Su et al., 2009) (P)
13. Unity in variety: Aaesthetic value or beauty depends on the fusion of various elements into an organic whole which produces a single impression. (*Unity in Variety*, n.d.) (P)
14. The pandemic have raised awareness of both physichal and mental well-being, in and outside of the home. (*7 Smart Home Trends For 2022 - Hippo*, n.d.) (D)
15. The majority of smartphone users want to reduce their screen time but few do anything about it. (Cohen, 2021) (D)

16. In todays society, smartphone in general, and social media in particular, can be linked to mental distress among the youth, especially girls. (Abi-Jaoude et al., 2020) (D)
17. Prioritizing girls' mental & physical health is more vital than ever. (*Prioritizing Girls' Mental & Physical Health Is More Vital Than Ever*, 2021) (D)
18. Reducing screen time does not only improve physichal health; it frees up time to play, explore, and spend time with family and friends. (Ayuob, 2022) (S)
19. Using a smartphone sets of a chain-reaction of further smartphone. (MacKay, 2020) (S)
20. Our general addiction to smartphones, awareness of its health implications, and the sense of always being connected, have made more and more people opt for a 'digital detox'. (*Ben's on His Phone 10 Hours a Day. Here's How a Digital Detox Could Help*, 2021) (D)
21. The pandemic has made it possible to work more from home (D)
22. Our increased time at home during the pandemic have changed the smart home market, making consumers demand a more holistic and convenient way to control the increasing number of smart devices. (*3 Ways the Pandemic Is Changing Smart Homes*, 2021) (D)
23. Privacy in smart homes is an important issue, leading to some manufacturers skipping voice control completely, all the while voice control is on the rise in general. (Hirt, 2022) (T)
24. Flic will release their smart home product Twist in 2022 that has "simple interactions, without voice controls, apps, or explanations". https://twist.flic.io (T)
25. For smart home interactions, touch-based interfaces are slightly less prefered than smartphone-based (70% vs. 80% preference respectively, 2019). (Statista, 2022) (T)
26. Millennials are willing to pay 20% or more for smart homes. (Wise, 2022) (T)
27. There is a movement to make all smart smart home products fully integrated, led by the new industry standard Matter (CSA) for release in 2022. (Hirt, 2022b) (D)
28. Smart home market is projected to have an annual growth of 12%. (Statista, n.d.) (D)
29. Consumers want smart homes to work seamlessly together. (Tuohy, 2022) (D)
30. The protocol Matter (CSA) will help make smart homes go from a niche market to being accepted at mass. (Tuohy, 2021) (D)
31. With the release of Matter, companies will need to innovate on top of the standard to create reasons for you to choose their devices over the competition. (Tuohy, 2021) (D)
32. Most smart home interaction is done through a smartphone app. (Statista, 2022b) (S)
33. Logitech's $250 smart home remote Harmony Express aimed for controlling the home theater with Alexa voice commands was discontinued in 2020 due to low acceptance of its main interface modality - speech. (Welch, 2020) (D)
34. Smartphones are used to control most things at home due to its versatility, unlimited possibilities, and widespread use. (Hern, 2021) (S)
35. Variety of smart home remotes are low and generally aimed toward controlling home-theater systems. (Katzmaier, 2022) (S)
36. Women emphasise the need for smart home interactions to be fast. pre-study (S)
37. Women emphasise the need for smart home interactions to be easy of use. pre-study (S)
38. Women emphasise the need for smart home interactions to have clear feedback. pre-study (S)
39. Women prefer a bright, rounded and minimal design for smart home interfaces. pre-study (S)

40. Smart home adoption is slow because users experience (or envision) usability issues. (Welinder, 2019) (S)
41. Smart home adoption is slow because it is generally envisioned by and for men. (Strengers, 2015) (S)
42. Smart home adoption has not met market expectations in recent years. (Shaham, 2022) (S)
43. Companies resort to stereotypes and assume women aren't tech early adopters; interpreting women as a smaller, softer human. (Alsever, 2020) (S)
44. Marketers frequently assume "women" are one homogeneous market. (Alsever, 2020) (S)
45. It is commonly perceived that "women and technology don't mix". (Deniz, 2019) (S)
46. Design teams are 81% male, generally leading to products designed for men. (Ely, 2018) (S)
47. Smart home products are mostly bought and used by men. (Zaman, 2021) (S)
48. Products to be held are generally designed to fit the size of male hands. (Turk, 2014) (S)
49. Women control up to 85% of consumer purchasing decisions and account for nearly half of all purchases in traditionally male-dominated categories such as cars and electronics. (Reporter, 2016) (S)
50. Voice control does not work as well for women as it does for men. (*Voice Recognition Still Has Significant Race and Gender Biases*, 2019) (S)
51. The culture of lightning-speed product development means few tech companies take the time to truly understand women, their lifestyles, and their needs. (Alsever, 2020) (S)
52. As technology has become increasingly complexh in recent years, the industry is aiming to return to minimalist user interfaces and self-explanatory operating patterns without sacrificing functionality. (Prestrich, 2021) (T)
53. Shy-tech interfaces are developed by BMW, among others; making interaction human-centred by allowing various surfaces and texutres to light up when interacted with. (*BMW Vision iNEXT*, n.d.) (T)
54. Women's earning power is growing faster than men's. (Alsever, 2020) (D)
55. Products that have better usability and high quality fair better on a competitive market. (S)
56. Simplicity drives growth as consumers are willing to pay more for uncomplicated experiences. (alison@uxmag.com, 2020) (S)

Summary of each factor type

TRENDS (7): Trends show there companies are trying to counteract smart home complexities by making interactions more simple and "analog", aiming to make interfaces feel less digital, be more private, and have self-explanatory operating patterns. Although smart homes are increasing in popularit, millenials are especially willing to pay more for smart homes.

DEVELOPMENTS (17): With smartphone use being connected with both physicla and metnal health, users want to reduce their screen time but few do anything about it. The impact of social media and smartphone use are linked to mental distress for the youth. With the ever-growing amount of connected devices in our smart homes, the need for all products to work seamlesslty together is adressed by the coming release of the new smart home standard Matter (CSA). It is believed that this change in the industry will help make the the smart home market go from niche to mass; projected to have an annual growth of 12%.

STATES (23): The majority of product Development are done by teams of men; still mostly catering to the needs of men, marketing to men, selling to men. The lack of focus on women's needs not only makes the current state of the industry unethical and unequal, it also makes companies loose out on a lot of potential profit. As many current and potential users experience a lack of usability in many smart home systems, companies still prefer to develop interactions that are app-based to the unlimited possibilites, and accesibility, of the smartphone. While there is an understanding that any one smarpthone interaction cause distractions, and foster further smartphone use, few efforts have been made to create alternative ways for controlling the smart home. Even though it is known that products encapsulating simplicity fair better on a competitive market, the industry consistently work to design app-based smart home solutions for tech-savy men.

PRINCIPLES (9): This need for simplicity is part of human nature, where human-product interactions become meaningful first when it becomes truly easy to use, intuitive, and appealing to our senses. Meeting this need while providing pleasant multi-sensory inputs, creates for a better percieved experience. Only then can we create a stronger emotional bond with a product, leading to product longevity and a sense of harmony in every interaction.

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Results of follow-up interviews

1. Profile

- 5 participants of age 18-64 (4 millenials + 1 GenX), most living with partner or family
- Living in 2-3 room apartments of approximately 75sqm

2. Meaning and moments

- Convenience is key to make smart home use simpler

3. Current SH use

- Phone used mostly but also have remotes for quick light control
- They have around 10 devices

4. Activities and tasks

- Lights (bright/color/scenes)
- Music (basic/recents/browse)
- Smart TV

5. General interaction needs

- Quick, reliable and self-explanatory control from one point
- Semi-limited (not too simple like Flic Twist and not too complex like smartphone)

6. Remote interaction remarks

- Simplicity is super important
- Device should make users feel confidence in use
- Some think serenity is good to achieve with a distraction-free device
- Some think companionship is good to feel positive bond with smart home
- Some think delight is good and attained by high quality materials and tactility

7. Remote qualities remarks

- Quick is very important for device to be desirable
- Self-explanatory good to not be ambiguos like some remotes
- Dynamic is good for increased capabilities and adaptability to various moments
- Trustworthy is important so user feels that it is reliable
- One user emphasised familiar as important for minimising time to learn
- One user emphasised tactile interfaces being more pleasant to use
- Enjoyable not mention particularly

8. Device placement

- Ability to leave it on dedicated spot on wall our counter
- Bringable to keep close by (similarly like the phone is used now)

9. Other devices comments

- The dynamic possibilities a touch-display brings is desirable
- High capability wanted but has to be intuitive
- Controlling everything from *one* app like Homey liked by everyone

10. Wearable

- A wearable was either deemed too limiting, too expensive, or not something they wanna wear

11. Pain points/comments

- All but one did not want to use voice commands
- One user did not use programmable buttons as symbols are not self-explanatory of use
- When devices (apps or remotes) do not work it is irritating
- If users install/setup devices, they feel higher confidence in using it
- Remotes give quick and clear tactile feedback, often with immediate results
- A wearable was either deemed too limiting, too expensive, or not something they wanna wear
- Feels natural to bring phone to every room, having it close by as one often does activites for a while in the same room

12. Needs selection

1. Want interface that is quick (efficient)
2. Want interface that is simple (but still similar capability as phone)
3. Want interface that is trustworthy (reliable)
4. Want a familiar device to reduce learning curve
5. Want tangible device for more comfortable feel (and quickness)
6. Want to do tasks with few clicks or steps (not dig down)
7. Want to adjust volume/lights on a physical device in only one move (not multiple clicks)
8. Want clear feedback of system status
9. Want interface with self-explanatory buttons
10. Want interface with dynamic buttons (due to wanting flexibility like a phone, looking at touch-display options now, adaptable to spatial/temporal)
11. Want interface that can be brought
12. Want interface with dedicated resting place (wall or counter, more?)
13. Want device that does not distract (serene, not wanna use phone)
14. Want a delightful device with high quality materials
15. Want to bring device as a complement to phone
16. Want to set an alarm clock without the need of a phone
17. Want to manually control the home according to mood
18. Want easy installation to increase chance of success and feeling gratification and confidence
    1. Want to control smart TV or similar
    2. Want to control (smart) speakers

3. Want to adjust brightness
4. Want to adjust colors
5. Want to select scenes or flows

13. **Extra notions**
    - Companionship more usable as marketing tool maybe
14. **Questions for further research**
        - Unclear what size is deemed good to not dissapear, to possibly fit in pocket etc
        - is clear tactile feedback truly wanted? is haptic or other shapes ok?
        - Unclear if basic control (play/next/forward/volume), recent, or browsing is needed (search does not seem to be needed)
    - Routes to explore questions in user journey?
        - Check time in each room: are users doing things in one room for longer = okay to bring device to each room in mornings and evenings?
        - maybe show a cluster of locations switching on top of morning use graph (see remarkable)
        - as phone is brought most often either way (will smart home heavy times like morning and evenings, moments, make it okay to bring the device
        - the HTA will show all devices brought around (important to do separately and time sensitive so one can see if they change rooms often.

Appendix 8: Needs and requirements

Needs and Requirements

#ID	Stage	Description	Need/want type	Need(want) or req.	Limits	Motivation, comment, source	Fulfilled?
F1	1	Want interface with dynamic buttons (due to wanting flexibility like a phone, looking at touch-display options now, adaptable to spatial/temporal)	Functionality	-		High capability wanted to be an alternative to the phone and existing remotes in the home.	
F2	1	Want interface that can be brought	Functionality	-		Feels natural to bring phone to every room, having it close by as one often does activites for a while in the same room. A wearable was either deemed too limiting, too expensive, or not something they wanna wear	
F3	1	Want interface with dedicated resting place (wall or counter etc)	Functionality	-		Just like the phone, users have routines and place devices in specific places generally.	NOT fulfilled
F4	1	Want to bring device as a complement to phone (and replacement for some times of the day)	Functionality			Phone will most often be brought either way. An extra device needs to be capable enough to act as a complement, or a replacement at times when disconnect is wanted.	NOT fulfilled
F5	1	Want to set an alarm clock without the need of a phone	Functionality			Setting an alarm with a tangible devices makes it possible to remove the phone from the bedroom at night	NOT fulfilled
F6	1	Want to manually control the home according to mood or activity	Functionality			Women want to feel in control of their living environment by being able to manually adjust it to fit the current mood or activity.	NOT fulfilled
F7	1	Want a device that is capable of adjusting the most commonly used smart home systems	Functionality			Want to control smart TV or similar, Want to adjust brightness, Want to adjust colors, Want to select scenes or flows, want to control speakers	NOT fulfilled
P1	1	Want tangible device for more comfortable feel (and quickness)	Pleasurability	-		Tangible devices give quick and clear tactile feedback, often with immediate results	
P2	1	Want device that does not distract (serene, not wanna use phone)	Pleasurability	-		Majority wants to disconnect and reduce smartphone use	NOT fulfilled
P3	1	Want a delightful device with high quality materials	Pleasurability	-		One user spoke of quality products provide better user experience	NOT fulfilled
R1	1	Want interface that is quick to control (efficient)	Reliability	-		Tangible devices give quick and clear tactile feedback, often with immediate results	
R2	1	Want interface that provides quick reaction times after input (efficient)	Reliability	-		Tangible remotes (and regular light switches) were prefered for its instant inititation after user input.	NOT fulfilled
R3	1	Want interface that is trustworthy (reliable)	Reliability	-		When devices (apps or remotes) do not work it is irritating	NOT fulfilled
U1	1	Want interface that is simple (but still similar capability as phone)	Usability	-		Convenience comes from quick and easy interaction	NOT fulfilled
U2	1	Want a familiar device to reduce learning curve	Usability	-		Familiarity decreases learning curve. An attractive product strikes a good balance between novelty and familiarity according to ViP.	Fulfilled
U3	1	Want to do tasks with few clicks or steps (not dig down)	Usability	-		Convenience comes from quick and easy interaction	NOT fulfilled
U4	1	Want to adjust volume/lights on a physical device in only one move (not multiple clicks)	Usability	-		Convenience comes from quick and easy interaction	NOT fulfilled
U5	1	Want clear feedback of system status	Usability	-		One user did not use programmable buttons as symbols are not self-explanatory of use. Self-explanatory higlhy regarded by all.	NOT fulfilled
U6	1	Want interface with self-explanatory buttons	Usability	-		Convenience comes from quick and easy interaction	NOT fulfilled
U7	1	Want easy installation to increase chance of success and feeling gratification and confidence	Usability			If users install/setup devices, they feel higher confidence in using it	NOT fulfilled
U8	2	Show recents, "picked for you" and/or favourites on each system	Usability			All tested apps start with a home screen catering to this to give users what they want without needing to look around	Fulfilled
F8	2	Device should be adaptable to time, space or user ot provide a personalised and efficient experience	Functionality			In addition to being dynamic in its use, one interesting idea from a participant was to have the device be time, place or user adaptable, meaning what functionalities are currently presented can change depending on the time of day, location in the home, or whoe the current user is. This might prove to be a good direction to make a device shareable in a more personal and effective way between multiple inhabitants.	NOT fulfilled
R4	2	needs to be better than phone, clicks (quicker, easier)	Reliability		<90 seconds	optimal was 65 seconds. UPDATE AFTER DOING AGAIN ON PHONE ACCORDING TO NEW TASKS	NOT fulfilled
R5	2	needs to be better than phone, time (quicker, easier)	Reliability		<60 clicks	optimal was 48 clicks . UPDATE AFTER DOING AGAIN ON PHONE ACCORDING TO NEW TASKS	NOT fulfilled
F9	2	needs to be capable of most phone tasks (set a timer, lights, music, tv, triggers)	Functionality			first draft of XD design provides for this	Fulfilled
R6	2	Big size to not dissapear, to possibly fit in pocket etc	Reliability			Secondary to providing good usability and ergonomics for women	NOT fulfilled
U9	2	Device needs to as usable for left and right handed people	Usability				
F10	2	Device needs to be customisable for personalisation (by setting up the home, but also for each individual of what can be done AND how it looks)	Functionality			more emotionally attached.	
U10	2	Provide feedback that clearly indicates the results of actions for every manipulation;	Usability			selected from affordance guidelines paper	
U11	2	Provide visual feedback that clearly indicates the selected function;	Usability			selected from affordance guidelines paper	
U12	2	Provide informative feedback that provides information on how to resolve an error;	Usability			selected from affordance guidelines paper	
U13	2	For safety-related functions and functions that take time to complete, provide multiple types of feedback (e.g., visual, auditory, and tactile feedback) to ensure that the feedback is clearly recognized;	Usability			selected from affordance guidelines paper	
U14	2	The brightness contrast between the text and the background should be at least 4.5: 1;	Usability			selected from affordance guidelines paper	
U15	2	Apply a color with high visibility to text that notifies of caution, error, or danger;	Usability			selected from affordance guidelines paper	
U16	2	Do not use more than four colors on one screen;	Usability			selected from affordance guidelines paper	
							NOT fulfilled
	3	Install by wps click or wifi password enter	Functionality				
	3	Connect to home(Google apple etc) automatically so lights, sonos radio or similar, nest, chromecast control possible	Functionality			wifi and bt	
	3	be able to browse songs in a playlists	Functionality				
	3	provide ways of setting different types of alarms (wake up, timer, etc)	Functionality				
	3	be able to adjust home temperature	Functionality			"styra tempen bra hade fått henne att köpa det"	
	3	Need to control all when internet does not work	Reliability				
	3	need to work with multiple devices in one home	Reliability			"Might need more than one in a big house"	
	3	need to function with interaction by one or two fingers	Usability			"users use one or two fingers for knob control"	
	3	back of device needs to provide grip	Usability			to use knob while laying down on table	
	3	a curvature on the bottom is needed to allow lifting and comfortable holding	Pleasurability		not too much s	curvature underneath is liked for lifting up and holding	
	3	length: resting area for grip handflata	Pleasurability		≤140mm? is that	the mockup length?	
	3	thickness	Pleasurability		≤1,5cm	"thinner if possible would be more aestethically pleasing, but making it too thin might also make it seem less capable; how thin it can become will also be shaped by how small components can be fitted"	
	3	Width	Pleasurability		min width ≥5m	"width was deemed ok and users did not want it to become too small" smaller would also not fit grid and text well	
	3	rubbery button use	Pleasurability			"rubbery buttons more prefered than hard plastic"	
	3	matte material use	Pleasurability			matte look and material feel preferred	
	3	Be able to click buttons when it lays on table	Usability				
	3	include audio feedback	Functionality			speaker to play items and give feedback	
	3	include tactile feedback	Functionality			users want to feel the interaction	
	3	include visual feedback	Functionality				
	3	design that makes cleaning it off easy	Reliability			one user said it needs to be easily cleaned	
	3	need to provide power without being pluggedin	Functionality			savant needed charging alot	
	3	the product requires less energy than if the same interactions would be done by a smartphone	Functionality				
	3	provide temperature and humidity measurements in the device	Functionality			women want to control temp, user wanted temp control	
	4?	shockproof					
	4?	technology for efficient digital communication				quick responsiveness of tasks	
	4?	technology for effective digital communication				high reliability of tasks being performed	
	5?	dirt resistance					NOT fulfilled
	5?	liquid resistance					NOT fulfilled

Appendix 9: Common smart home control

System functions

Legend

- MD = multidirectional
- V = vertical
- H = horisontal

Typical tasks for adjusting lights

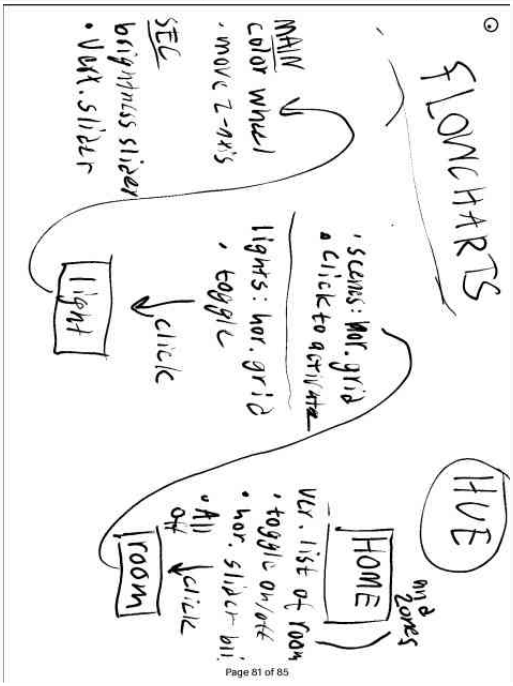
Light tasks to design flow for (and future testing)

1. Adjust brightness in a specific room (excluded in calculation) (DONE LAST)
2. Adjust brightness and color of specific light
3. Activate specific scene for a room/zone
4. Turn off lights in a specific room

Table of task steps and figures of app

Task steps / System	Philips Hue	Homey	Philips Hue remote	Wall dimmer	*Summary*
1 Toggle off room	Click room toggle	[N/A]	[N/A]	Only in current room	Only Hue that can do this
2.1 Select room/zone	Click room	[N/A]	[N/A]	[N/A]	Hue only room/zone grouping
2.2 Select light	Click light	Longpress light	[N/A]	[N/A]	Homey takes longer to adjust lights (although all lights available on home screen)
2.3 Brightness	Vertical slider	Vertical slider	Click up/down	Rotate knob	Most use step-free adjustment (sliders or knob)
2.4 Change to color	*no action needed*	Horisontal swipe	[N/A]	[N/A]	Quick access in Hue
2.5 Color	2-axis wheel	Click presets	[N/A]	[N/A]	Step-free adjustment in Hue (faster and quicker acess on same screen as brightness)
3.1 Go back	Click (x) back	Click (<back)	[N/A]	[N/A]	Back needed to exit light as bottom tabs are hidden on this creen.
3.2 Activate scene	Click scene	Click scene(flow)	Click on (toggle)	[N/A]	Scenes not available on wall dimmer
4.1 Go back	Click (<-) back	[N/A]	[N/A]	[N/A]	Homey has scenes on same screen as lights
4.2 Turn off room	Click room toggle	[N/A]	[N/A]	Click knob toggle	Homey and remote cant turn off specific room
Time & interactions	15 sec & 8 interactions	*not calculated*	*not calculated*	*not calculated*	
Visual feedback	medium text: toggle greyed out (or white) card, sliding changes color/brightness bg, color wheel dot more clear on which color is used, vert. slider shows level increasing/ decreasing	small text: toggle greyed out (or white) cardcolor choice in the middle (but a bit messy with other color , dots surrounding	light lighting up on click	[N/A]	Hue has the most clear feedback while Homey is a bit cluttered
Tactile/haptic feedback	subtle vibration on toggle	subtle vibration on toggle and click	fiddly plasticky tactile mechanism (clicking on edge of button does not click as well)	Plasticky mechanichal requiring too much force	Homey provides a haptic feedback on every action, tangible devices lack quality feel
Auditory feedback	[N/A]	[N/A]	From mechanical click	From mechanical click (not while dimming)	All lack possibility for auditory feedback

Analysis	*Most intuitive but lacks some haptic feedback*	*Quicker light selection but lacking zones/rooms*	*Quick brightness adjustment but very limited and no feedback*	*Quick brightness adjustment but most limited and no feedback*	*Hue is quick and easy to use but lack more haptic feedback*



Light adjustment remarks

- Light actions are carried out instantly upon slide or click commands
- Hue was the only app that could perform all tasks and is thus used as an interaction benchmark: 8 interactions (+1 for choosing the light system)
- Hue system potential efficiency time is ≈15 sek (for task 1-4)

Typical tasks for adjusting audio

Audio tasks to design flow for (and future testing)

1. Select media to play from
2. Play specific playlist (own playlist landscapes)
3. Select two speakers for playback
4. Increase volume on speaker
5. Skip song

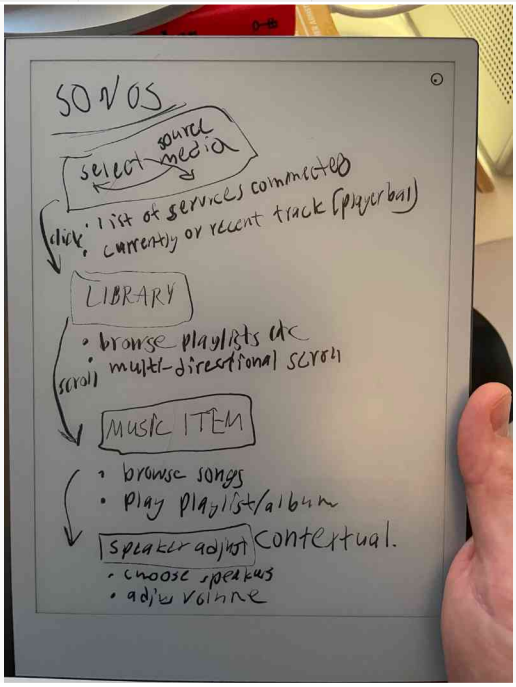
To consider for future audio designs

- like current song
- start song radio from current
- toggle shuffle playlist
- toggle various repeat options
- (add other song to queue)

Table of task steps and figures of app

Task steps / System	Sonos	Spotify	Big jambox speaker (BT)	*Summary*
1 Select media source	Click Spotify	[N/A] (podcasts etc available)	[N/A]	Just like choosing different apps for playing audio on a BT or WIFI speaker, Sonos is designed to show sources like radio apps, Soundcloud, Spotify etc inside.
2.1 Browse music item sections	Scroll to own playlists (≈3 scrolls)	(available but library is better for browsing a lot)	[N/A]	Multi-directional scroll used in both
2.2 Enter list of your playlists	Click "your playlists" header	Click "Library"	[N/A]	-
2.3 Browse your playlists	Scroll to Landscape playlist (≈3 scrolls)	Scroll(or click through folders) to Landscape playlist (≈3 scrolls)	[N/A]	Spotify keeps a vertical scroll list with smaller items while Sonos has large item covers for vertical scroll
2.4 Select Landscapes playlist	Click playlist cover	Click playlist cover	[N/A]	-
2.5 Play playlist	Click play (or shuffle play)	Click shuffle play	Click play/pause button	Spotify shuffles playlists automatically (not albums)
3.1 Show what is playing	Click bottom player bar	*no action needed*	[N/A]	-
3.2 Change speaker choice	Click lower bottom speaker icon	Click lower bottom speaker icon (on bottom info bar)	[N/A]	Spotify fewer clicks needed to reach speaker page
3.3 Select both speakers	Click "Living Room"	Click ... to open options, click arrow to open Sonos, click "Living Room"	[N/A]	For multiple speakers Spotify cant do it
3.4 Confirm choice	Click "done"	Click "done" (opens Spotify again)	[N/A]	Why does it not play instantly on speaker select?
4.1 Show speaker volumes	Click volume bar	[N/A] (only one main volume)	[N/A]	-
4.2 Adjust living room volume	Vertical slide on living room volume bar	Exit Spotify, open Sonos, click player bar, click volume bar, slide volume (≈4 interactions)	Click up or down buttons	Side buttons on iphone could've been used as alternative
5.1 Skip song	Click next button	Click next button (in Sonos, otherwise more interactions are needed)	Click next button	-
Time & interactions	20 sec & 17 interactions	*not calculated*	*not calculated*	-
Visual feedback	Medium text: player bar shows speakers playing in big font with song + artist smaller below	Medium text: player bar shows in song + artist in big font with while smaller speakers playing below. Playback icon also visible (speaker, computer, headphones)	[N/A]	Sonos and Spotify similar as the former copies the latter. Spotify uses space better to present the wanted features at the right place.
Tactile/haptic feedback	Many small haptic responses for each percentage when sliding volume	None (volume is changed on side of iphone with high quality mechanical feel)	Rubbery quite stiff mechanical button presses with relatively distinguishing shapes. No haptics	Volume haptics on Sonos was appreicated (but maybe too much for each percentage), physichal buttons of BT speaker made interaction without looking possible

Auditory feedback	[N/A]	[N/A]	Short sound for each click, other sound for switching song, other sound pausing, other sound for play	Only the tangible controls provided auditory feedback; also with individual sounds for each task to distinguish what is happening
Analysis	*Entering the Spotify media took some loading, otherwise clear feedback (style copied from Spotify). Player bar emphasises speakers used*	*Spotify feels more responsive, refined and feature rich than Sonos. More options available on now playing page. Adjusting multiple Sonos speakers not working.*	*Basic playback features like play/pause/next/previous + volume is instantly available*	Tangible button of BT speaker provide fastest interaction for basic commands while Spotify provides more capabilities *and* feedback



Audio adjustment remarks

- Distinguished sounds for each interaction good (bt speaker)
- Clicking the home/library button twice in Spotify makes the scroll go back to the top
- spotify starts from home-screen if app is quit (sonos start on Browse screen by choice)
- volume adjust sonos fades away after a few seconds
- Sonos takes some time to load in Spotify (not wanted)
- Volume and browsing not using the same input device (side volume buttons + touch display)
- Sonos was the only app that could perform all tasks and is thus used as an interaction benchmark: 17 interactions (+1 for choosing the overall audio system(not a media))
- Sonos system potential efficiency time is ≈20 sek (depending on where scroll of library is) (for task 1-5)

Typical goals for adjusting TV

TV tasks to design flow for (and future testing)

1. Select media to play from

2. Select user account
3. Play specific item
4. Select device for playback
5. Change playback item
6. Change subtitles
7. Increase volume

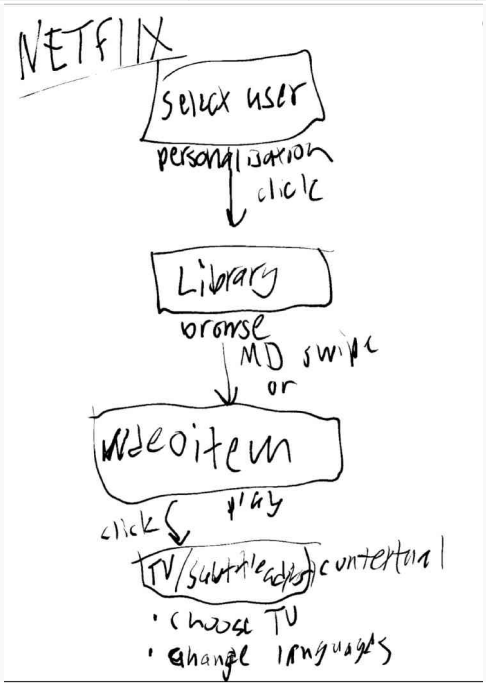
To consider for future TV designs

- how to mute

Table of task steps and figures of app

Task steps / System	**Netflix app**	**TV control (Chromecast)**	***Summary***
1 Select media source	(open app)	Click Netflix (middle)	-
2 Select user	Click wanted user	Click wanted user (middle)	-
3.1 Browse items	MD swiping (≈5)	MD clicking (≈5)	Swiping puts browsing in a spin, meaning more content can be browsed faster
3.2 Select item	Click item	Click item (middle)	-
3.3 Play item	Click play (or similar) (auto-plays after a while)	Click play (middle) (auto-plays after a while)	-
4.1 Select device for playback	Click "cast" icon top left	*no action needed*	Similar to audio playback, the device for playback can be chosen earlier or after an item has started playing
4.2 Select device	Click Living Room TV	*no action needed*	
5.1 Exit item	Click (x)	Click (←)	(x) shown in different corners and hard to reach by one hand
5.2 Go to browsing	Click (x)	Click (←)	Back easily reached on the remote
5.3 Browse items	MD swiping (≈5)	MD clicking (≈5)	Using MD navigation demands less thumb motion from the user
5.4 Select item	Click item	Click item (middle)	-
5.5 Play item	Click play (or similar)	Click play (middle)	-
6.1 Adjust subtitles	Click touch display	Click middle button	-
6.2 Open subtitles options	Click subtitles	MD clicking (≈3)	With limited browse options here it is easier for users to click on the right choice on a phone instantly
6.3 Select desired language	Click english subs	MD clicking (≈3)	-

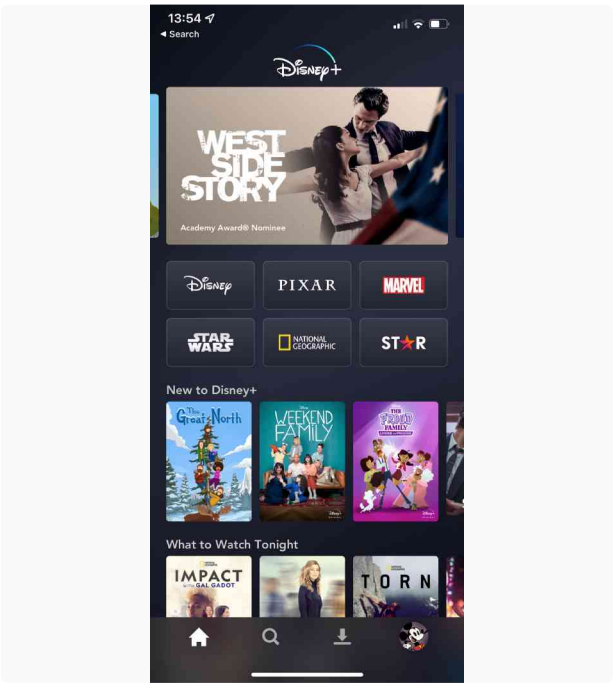
6.4 Close menu	Click (x) upper right	*no action needed*	
7.1 Adjust volume	Click volume up on side	Click volume up on side	Done exactly the same, works no matter where in the interface
Time & interactions	35 sec & 23 interactions	30 sec & 26 interactions	Phone took longer due to more loading even though TV and phone was one same network. TV took a few more clicks to alter subtitles. Swiping can digest more content quicklier as content scrolls by automatically after just one swipe.
Visual feedback	A lot of information but one quickly learns how to interpet and use it all	Symbols on all but MD buttons. Clear meaning except for assistant.	-
Tactile/haptic feedback	None	Rubbery round with mechanical click	
Auditory feedback	None	[N/A] (click sound while moving on chromecast home)	Maybe the high amount of scrolling/swiping has left Netflix not wanting to have haptics/ sounds all the time?
Analysis	*Browsing by swiping is fast and a good alternative to the remote browsing on a tv*	*Allowing for a similar experience but free from the phone, phone neck, and distractions*	Very similar use but be wary that other video apps work differently, though all that are controlled on a smart TV are so by use of a d-pad device

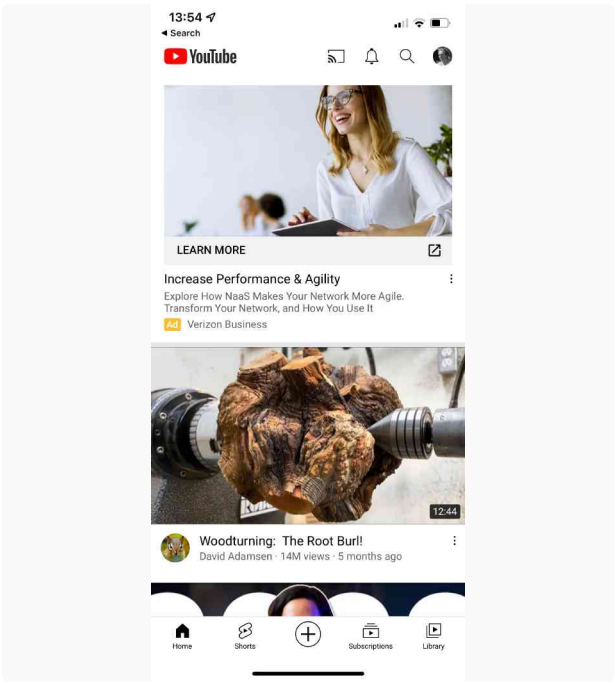


- *Flowchart with images above for presentation and report*

TV adjustment remarks

▼ Although services like Netflix, HBO Max and Disney+ operate similarly, Youtube and other services operate differently making a more flexible interaction desirable, for example, the MD navigation, aka, directional pad (d-pad).





- iphone requires two hand use as (x) to go are hard to reach (and switch locations)
- adjusting volume at anytime from anywhere wanted like on a tv remote
- Netflix takes slightly more time to load on smartphone app compared to on Chromecast app
- Netflix on phone or TV with remote had similar results to be used as an interaction benchmark: 23 interactions (+1 for choosing the video media source)
- Netflix system potential efficiency time is ≈30 sek (depending on where scroll of library is) (for task 1-7)

General remarks about task analysis (lights, audio, tv)

- All first steps to open an app are omited
- In some cases, vertical or horisontal scrolling was needed to reach a specific zone/room/light, while audio and tv control requireed more scrolling frequently (which is why estimates were included in tables)
- feedback remarks (environmental feedback not included)
- long press is used to mimic left-clicking to reach contextual menus or options (source

Design priorisation according to system difference

- lights have a limited set of items (rooms, lights, zones) that are often viewed in a grid of cards (lights most often used)
- lights will shape the design of grid-based device
- next: music and tvs have infinite array of items to browse
- as tvs can be controlled by MD navigation on TV it has lower design priority than music (music also more often used)

- priority for music (and tv) use is to use grid for recents or favorites or similar (just like lights will have flows or zones)
- how to browse large arrays of items can be explored as done in grid (or by knob scroll with items viewed as single line on display OR as multiple on page grid or larger display)

Remarks about usability in remotes

- Simple, few button design [U1] (figure X remotes)
- Use of familiar elements like the d-pad [U2] (figure X remotes)
- Use universal icons with text labels for clarity [U6]
- Provide key information consisely using familiar terms [U5]
- Organize menus hierarchically
- Provide 'all off'(power off) and 'home' buttons?
- Provide back/cancel to easily reverse actions
- playback device is used for audio and TV; dedicated button for this is beneficial
- IMPORTANT: All apps consistently have a Home screen showing recents or facourites (updated in accordance to use)
- Personalisation of experience by use of user accounts (like Sonos links to various accounts - even multiple Spotify accounts)

General exclusions from design considerations

- search by voice, typing, etc
- sharing content to others
- editing play queue

Smart home control subtasks

First user decides what to do and then selects a system to control

- **Quick options**
  - see status
  - turn all off or mute
  - select user
  - activate automations
- **Adjust lights**
  - (find items: usually not many to browse through)
  - toggle zones/rooms/lights on or off
  - contextual options
    - adjust brightness
    - adjust color
- **Play audio media**
  - find what to play
  - skip songs, pause etc
  - contextual options
    - playback device
    - set shuffle or repeat
    - like song, queue a song (or album/playlist)
    - adjust volume
  - **Play tv media**
    - find what to play
    - skip, pause etc
    - contextual options
      - playback device
      - set subtitles or spoken language
      - like show
      - adjust volume
    - Generic control
      - find parameters
      - adjust paremeters (temp, alarm etc)

Quick sketch evaluation

Hi dear diary participants!

Based on your insights, I have designed three early concept ideas I want to evaluate before going forward. If you have 5-10 minutes to get an understanding of the 3 concepts, and which you prefer, it would be very heplful to me! Det går bra att svara på svenska :)

Concept background

1. Main idea is to make the device familiar by shaping it like a remote you can hold but also be able to use when it is laying down or is placed on a wall mount.
2. The goal is to design the interface so the device feels intuitive for contorlling lights, audio, and tv.
3. To make the remote dynamic for different use cases, all buttons have tiny displays that can change what it shown.
4. Think of it as the size of iPhone mini or similar.
5. The main difference for each concept is marked in red text.

Please look at the images, understand the concept, then think of the common tasks (listed on top in each image) and assess which one you prefer.

Questions

1. Does the general interaction flow seem okay?
   Flow: Choosing a system like lights or audio to control, then seeing new options below with the ability to adjust volume, brightness etc by being able to slide, scroll or rotate. Please motivate shortly and if you do not like it let me know :)
2. Which one do you prefer? (scroll, knob, or slider) Please motivate shortly.
3. Which one do you prefer the least? Please motivate shortly.

Thank you very much for helping out!

Responses on sketches

User / question	Does the general interaction flow seem okay?	Which one do you prefer?	Which one do you prefer the least?
1	I första anblick ser det mycket ut men när jag läst beskrivningarna för alla delar verkar det enkelt och alla valen upplever jag kommer i en naturlig ordning uppifrån och neråt. Och innehåller de delar som behövs.	Jag gillar slider bäst. Det är nog för jag är van vi den rörelsen och det känns som den är mest känslig - att en hittar de nivå/styrka en vill mer exakt. Och det gör kontrollen mer platt och estetiskt snyggare.	Knob gillar jag minst för den är lite motsatt till slider. Kontrollen tänker jag mig känns lite större. Och (även om det inte behövs, och nog endast i början) per automatik använder två händer pga vanan att använda både långfinger och tumme när en skruvar på något.
2	Jag tycker om koncepten! Smart att göra något familiar på det sättet men ändå dynamiskt. Tycker om att det blir som ett flow från högst upp till längst ner på kontrollen, så man kan kolla status, välja system osv ganska dynamiskt. Det är bra att pilarna är halvvägs upp på kontrollen eftersom det blir skönare i handen att sträcka sig efter dem.	Det hade nog varit enklare att säga om det var en fysisk prototyp, men finns fördelar och nackdelar med alla. Jag tycker att fysiska reglage är nice, så då är 1 och 2 nice. Finns en risk med 2:an att man måste använda två händer när man håller i den vilket kanske inte är så nice, men föredrar generellt ett sånt reglage. 1:an beror på implementationen. Har en fjärrkontroll med diskreta "klick", men scrollar nästan aldrig med den utan klickar hellre med knapparna. Scrollhjulet har dessutom en knapp som är det enda sättet att välja, så scrollar oftare av misstag än med mening. Men om det är en mjuk scroll som en Marshall högtalare så är det en annan sak. Då kanske koncept 1 både gör det möjligt att ha en fysisk knapp och att scrolla med bara en hand. 3:an är väl det säkra alternativet, och ger möjlighet att hoppa direkt till den volymen eller ljusstyrkan man vill ha, men ger inte samma feeling som 1 och 2.	
2		Så tycker om 1 bäst om det implementeras väl och 2 minst.	2 minst
3			
4			
5			
Summary		En gillar 2:an men är rädd att den inte kommer användas väl med en hand	Knob kan bli lite stor och klumpig.

Heuristic expert evaluation results

Setup: all 4 users tested the interface on a smartphone to mimic a remote, two senior and one junior ux designers and one junior industrial design engineer

1. Visibility of system status (1,75: Minor)

- 1A: Knowing which specific lights are hidden behind pages. Varied opinions on how the status of lights/rooms are clear or not
- 1B: Status bar on top seems secondary due to its smaller size
- Gold (as used the same way on all buttons) was interpreted as a selection, not the current color of the room

Suggestions

- change 'some' to specific number (or names)
- Dark grey does not seem like a selection (rather off)
- Look at Apple TV or Fire TV on how basic commands are done
- Increase the size of status bar to give it more attention

2. Match between system and the real world (1,75: Minor)

- 2A: Cycling on contextual buttons wasnt consistent
- 2B: using the knob is probably for volume, but can I do it on the side of device or grid?
- 2C: common to have device selected so playing an item gives instant feedback
- 2D: like modular button texts for increased clarity (like 'exit lights' instead of just 'exit)

Suggestions

- Either use context buttons as tabs, or emphasise the cycle-type interaction
- Want to select device first

3. User control and freedom (0,75: Cosmetic)

- The order of selections was sometimes unclear, like when having to select what to watch or listen to before selecting the playback device.
- 3B: irritating when wanting to go back to start but can only go one step back

Suggestions

- provide for both flows of selecting device first or after
- want way to go back one step AND go back to start (home)

4. Consistency and standards (1,5: Minor)

- Meaning of toggling between lights, scenes, brightness and color a bit unclear. Especially knowing that rotating knob adjust brightness or color
- functions and language were clearly distinguishable

Suggestions

- Either use context buttons as tabs, or emphasise the cycle-type interaction

5. **Error prevention [N/A] (1,5: Minor)**
   - I do not prefer systems with too many confirmation steps (meaning device selection?).
   - Hard to evaluate properly with such a limited prototype.

   Suggestions
   - Test this again with a more complete version
   - Keep number of interactions in processes to a minimum and do not use confirmation option unless a critical action is selected such as factory reset or other.

6. **Recognition rather than recall (1,25: Cosmetic)**
   - The cycling buttons and the flow for playback felt a bit unnatural
   - The display on the top is a bit small and it took me some time to realize that it was there and showed the status of what i was doing down underneath the knob,

   Suggestions
   - Maybe put the statusbar underneath the categories, so the user dont have to move their eyes across the whole device

7. **Flexibility and efficiency of use [N/A] (1,25: Cosmetic)**
   - Device is most likely used multiple times per day and will then result in all users eventually becoming experienced users.
   - Hard to tell in this early stage

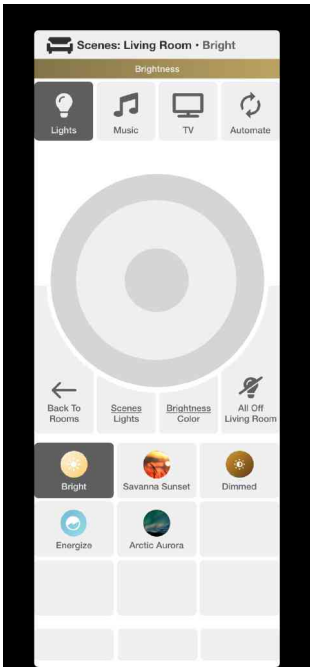
   Suggestions
   - Design the device so that it grows with you. Gives the impression of a device that gets smarter and smarter.

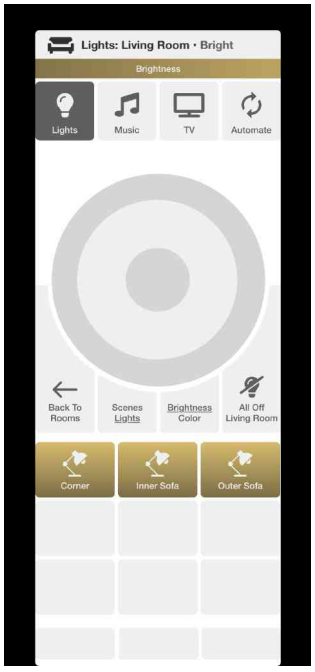
8. **Aesthetic and minimalist design (0,25: None)**
   - Could even have more information, especially in the automation tab where some buttons were unclear
   - In Automate the information of what is selected in each room is shown both with icons and text which makes the view a bit cluttered.

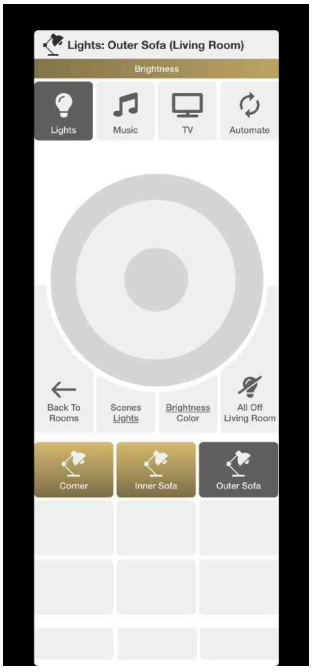
   Suggestions
   - Choose either text or icons. Since text is truncated maybe icons are a better option for these buttons.

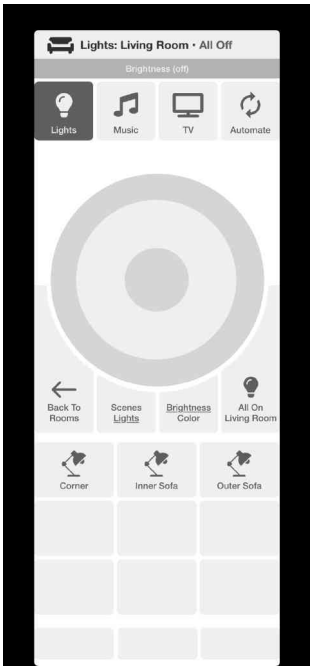
9. **Help users recognize, diagnose, and recover from errors [N/A]**
10. **Help and documentation (0,5: Cosmetic)**
    - I didn't feel the need to search for help or extra documentation. It seems intuitive.
    - The device was usable without documentation, and did not feel like it would need any

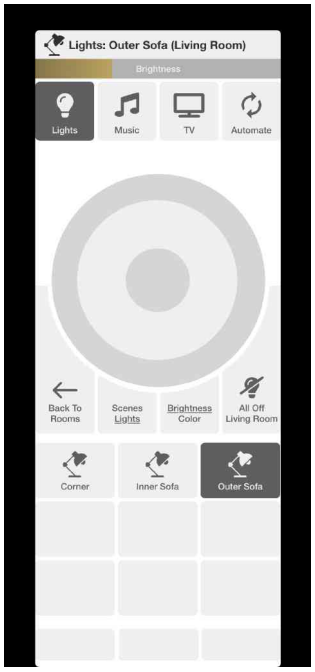
Appendix 13: Interface design v1

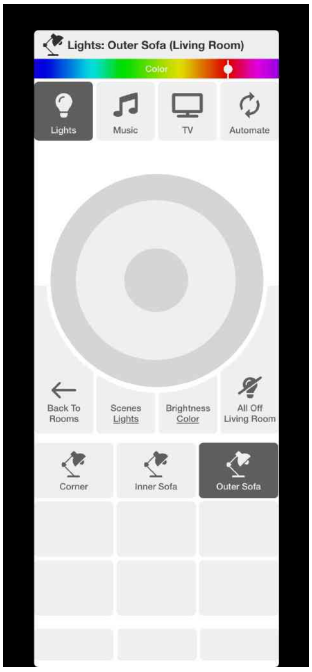


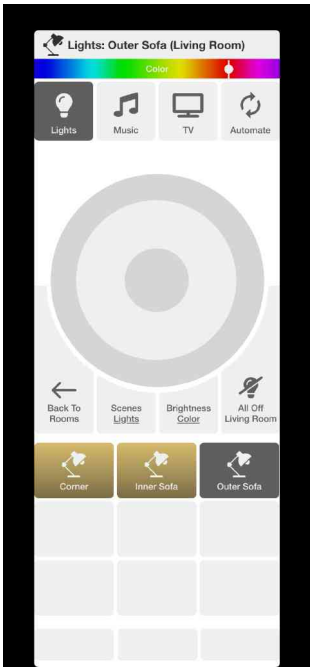


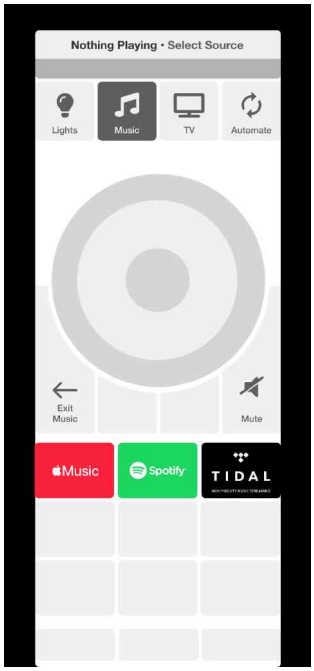


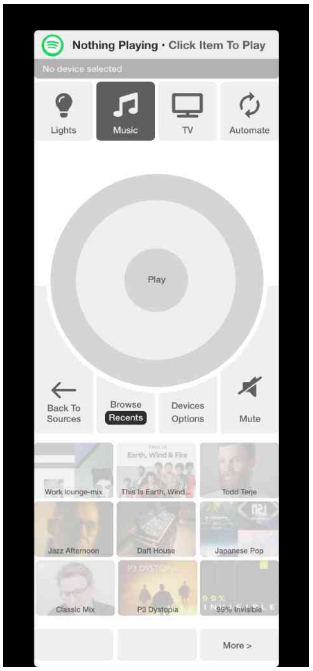


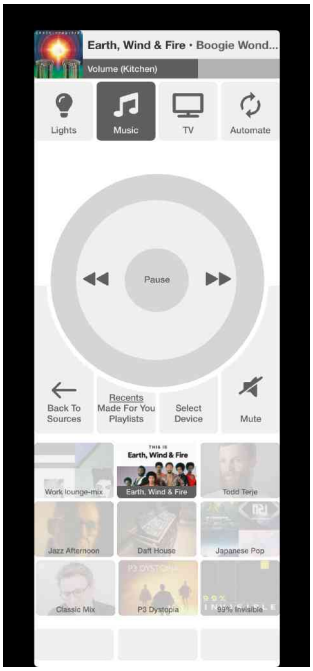




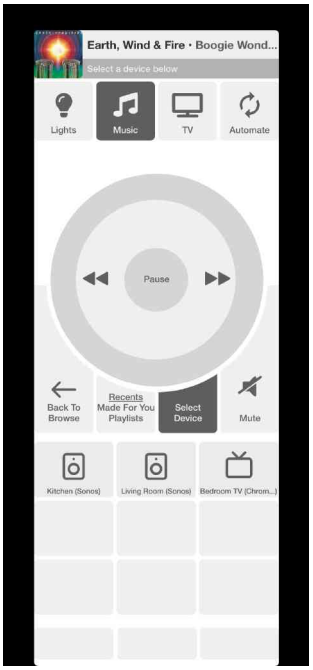



Nothing Playing • Select Source
Lights
Music
TV
Automate
Exit Music
Mute
Music
Spotify
TIDAL


Nothing Playing • Click Item To Play
No device selected
Lights
Music
TV
Automate
Play
Back To Sources
Browse
Recents
Devices
Options
Mute
Work lounge-mix
This Is Earth, Wind...
Todd Terje
Jazz Afternoon
Daft House
Japanese Pop
Classic Mix
P3 Dystopia
99% Invisible
More >

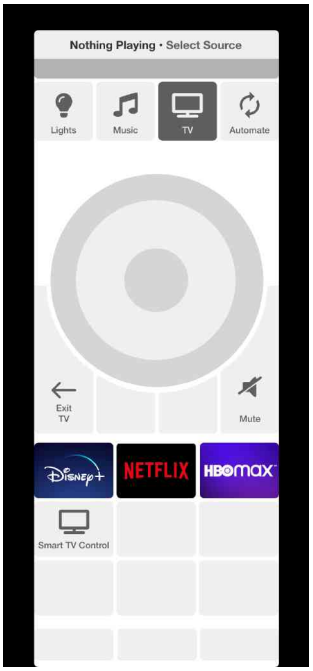

Earth, Wind & Fire • Boogie Wond...
Volume (Kitchen)
Lights
Music
TV
Automate
Pause
Back To Sources
Recents
Made For You
Playlists
Select Device
Mute
Work lounge-mix
Earth, Wind & Fire
Todd Terje
Jazz Afternoon
Daft House
Japanese Pop
Classic Mix
P3 Dystopia
99% Invisible

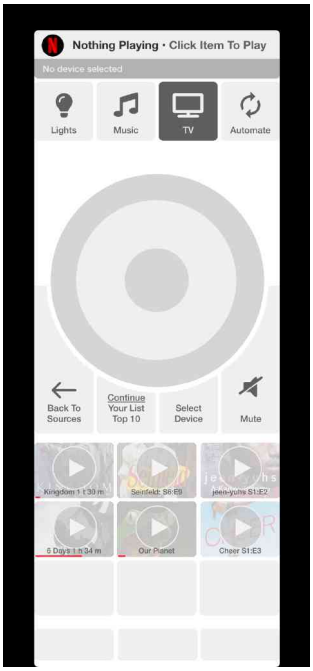

Our Planet (32 m left)
No device selected
Lights
Music
TV
Automate
Select
Back To Browse
Continue
Your List
Top 10
Select Device
Mute
Bedroom TV (Chrom...)

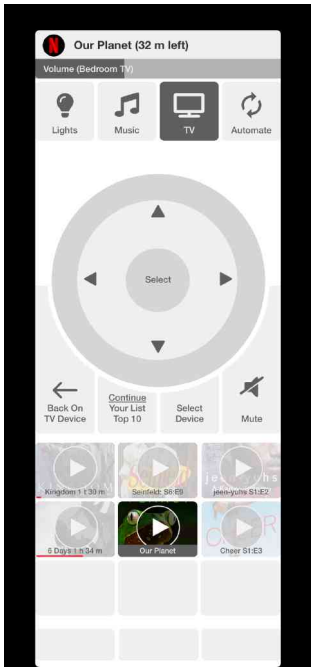

Earth, Wind & Fire • Boogie Wond...
Select a device below
Lights
Music
TV
Automate
Pause
Back To Browse
Recents
Made For You
Playlists
Select Device
Mute
Kitchen (Sonos)
Living Room (Sonos)
Bedroom TV (Chrom...)

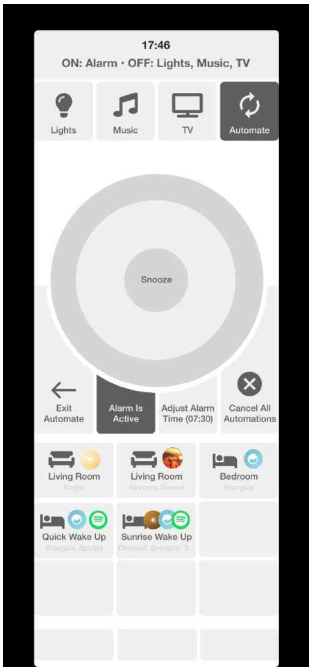

Our Planet (32 m left)
Volume (Bedroom TV)
Lights
Music
TV
Automate
Select
Back To Continue
Continue
Your List
Top 10
Select Device
Mute
Bedroom TV (Chrom...)


Earth, Wind & Fire • Boogie Wond...
Volume (Kitchen)
Lights
Music
TV
Automate
Pause
Back To Recents
Recents
Made For You
Playlists
Select Device
Mute
Kitchen (Sonos)
Living Room (Sonos)
Bedroom TV (Chrom...)

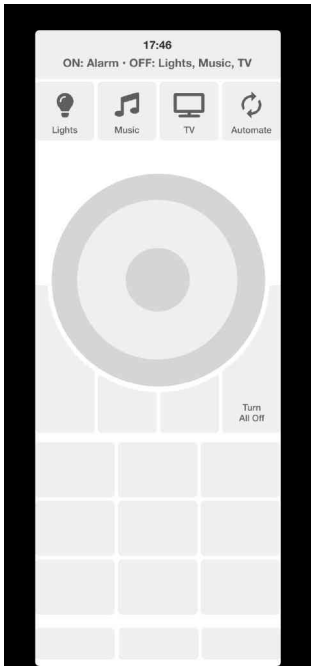

Nothing Playing • Select Source
Lights
Music
TV
Automate
Exit TV
Mute
Disney+
NETFLIX
HBOmax
Smart TV Control


Nothing Playing • Click Item To Play
No device selected
Lights
Music
TV
Automate
Back To Sources
Continue
Your List
Top 10
Select Device
Mute
Kingdom 1 1:30 m
Seinfeld: S8:E9
6 Days 1 n 34 m
Our Planet
Cheer S1:E3


Our Planet (32 m left)
Volume (Bedroom TV)
Lights
Music
TV
Automate
Select
Back On TV Device
Continue Your List Top 10
Select Device
Mute
Our Planet
Cheer S1:E3


17:46
ON: Alarm · OFF: Lights, Music, TV
Lights
Music
TV
Automate
Snooze
Exit Automate
Alarm Is Active
Adjust Alarm Time (07:30)
Cancel All Automations
Living Room
Living Room
Bedroom
Quick Wake Up
Sunrise Wake Up


Main title · Subtitle
Playback device etc
Lights
Music
TV
Automations
Volume
Click OK
Back
Option 1
Option 2
Mute
Item X

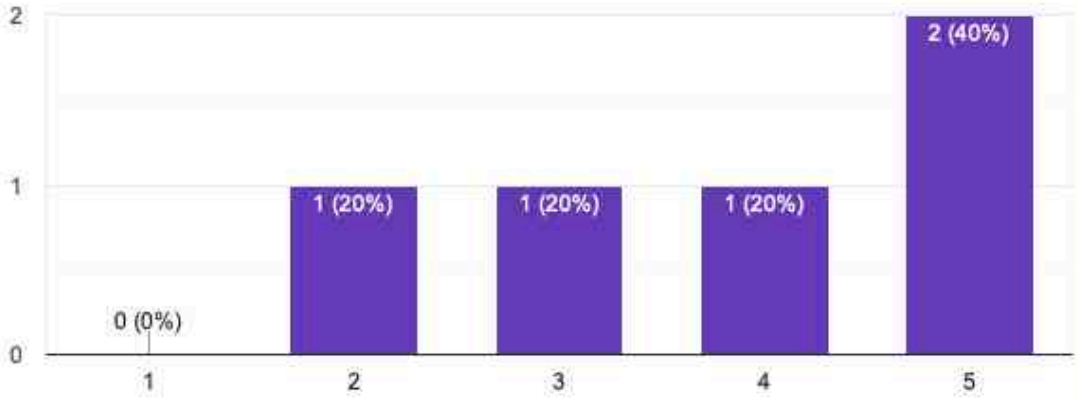

17:46
ON: Alarm · OFF: Lights, Music, TV
Lights
Music
TV
Automate
Turn All Off

System Usability Scale

1. I think that I would like to use this system frequently.

Copy

5 responses



2. I found the system unnecessarily complex.

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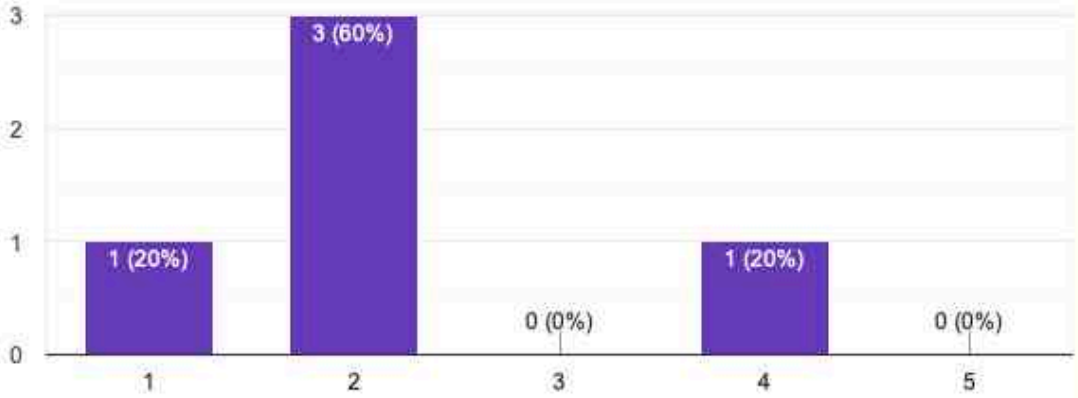
5 responses



3. I thought the system was easy to use.

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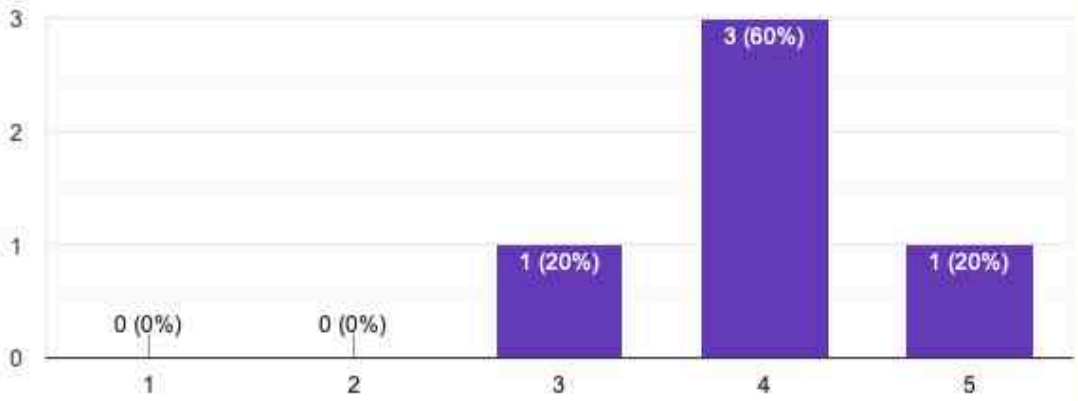
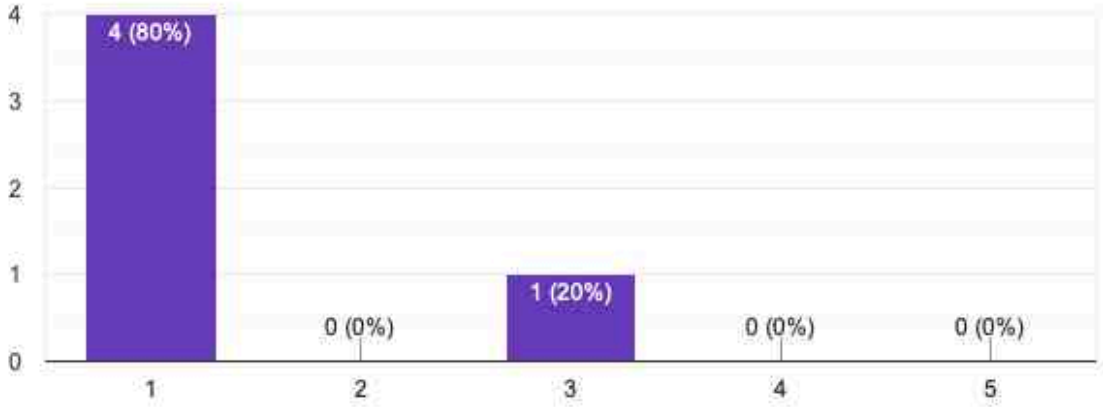
5 responses



4. I think that I would need the support of a technical person to be able to use this system.

Copy

5 responses



5. I found the various functions in this system were well integrated.

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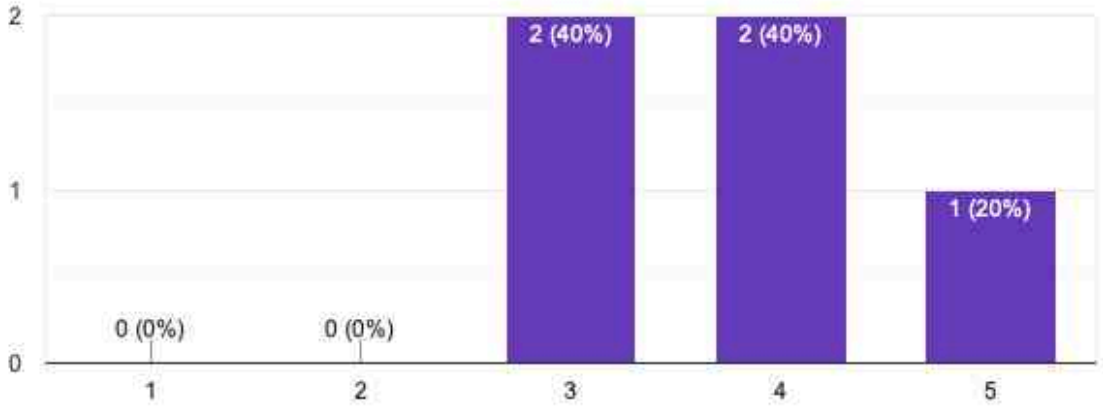
5 responses



6. I thought there was too much inconsistency in this system.

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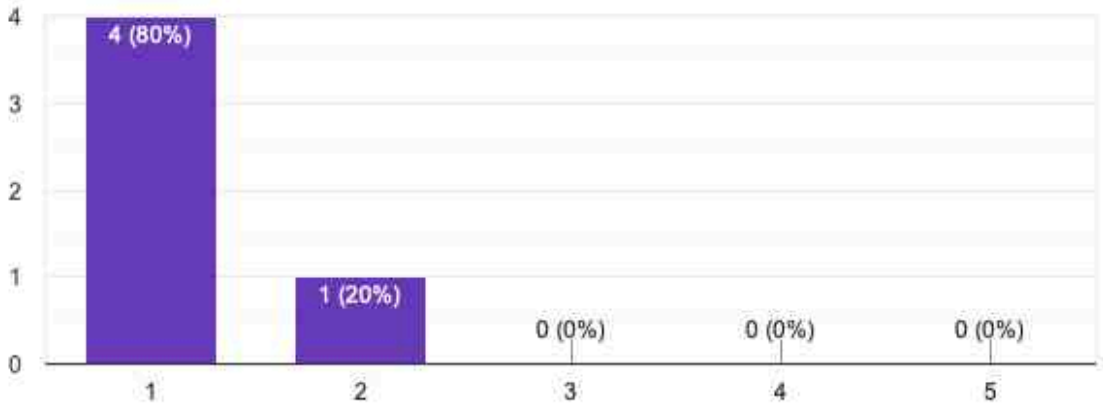
5 responses



7. I would imagine that most people would learn to use this system very quickly.

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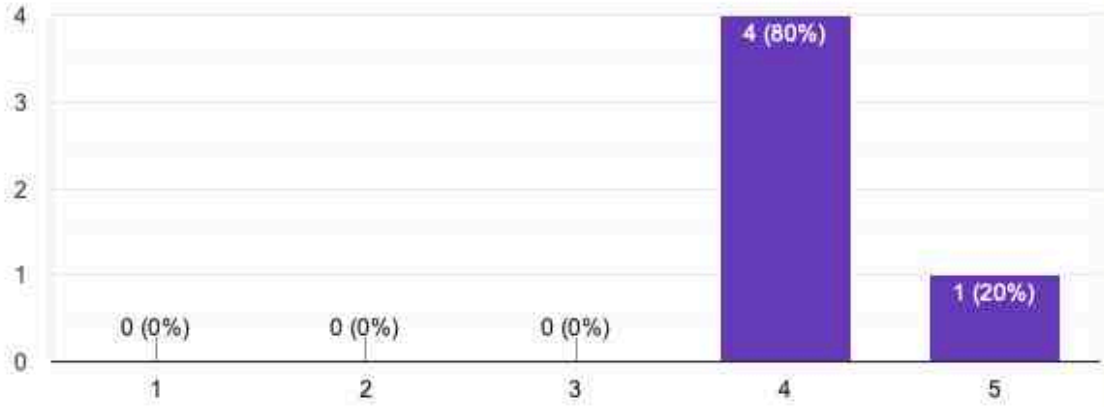
5 responses



8. I found the system very cumbersome to use.

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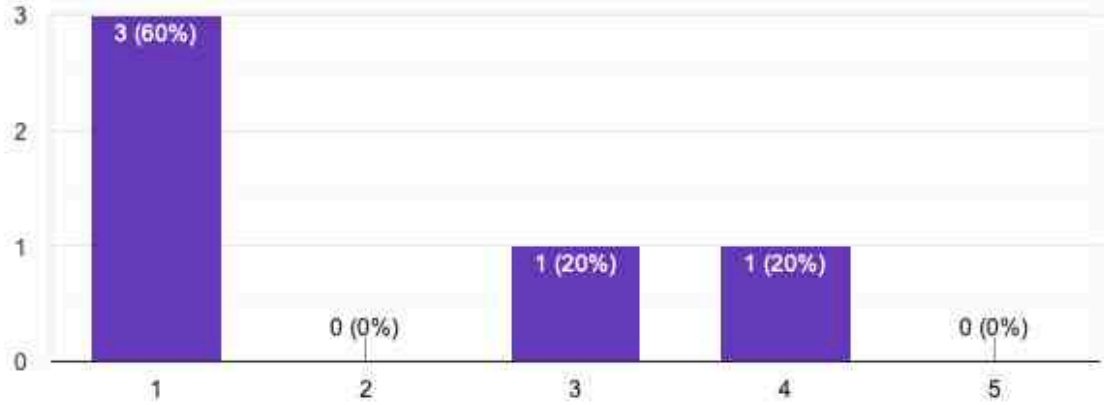
5 responses



9. I felt very confident using the system.

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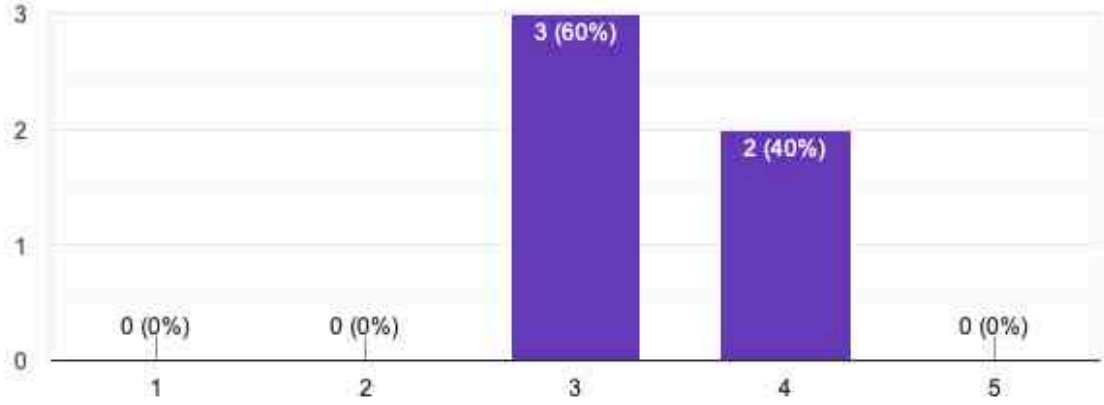
5 responses



10. I needed to learn a lot of things before I could get going with this system.

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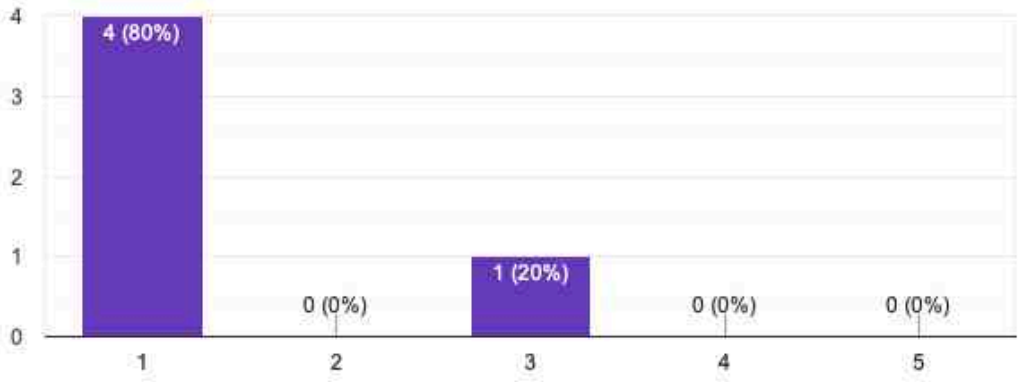
5 responses



Choose on the scale which words best describe the interaction

Simple vs Complex

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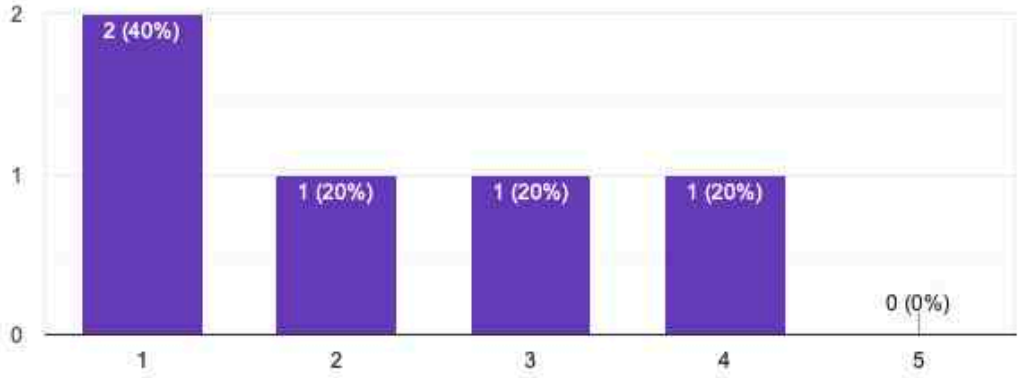
5 responses



Familiar vs Unfamiliar

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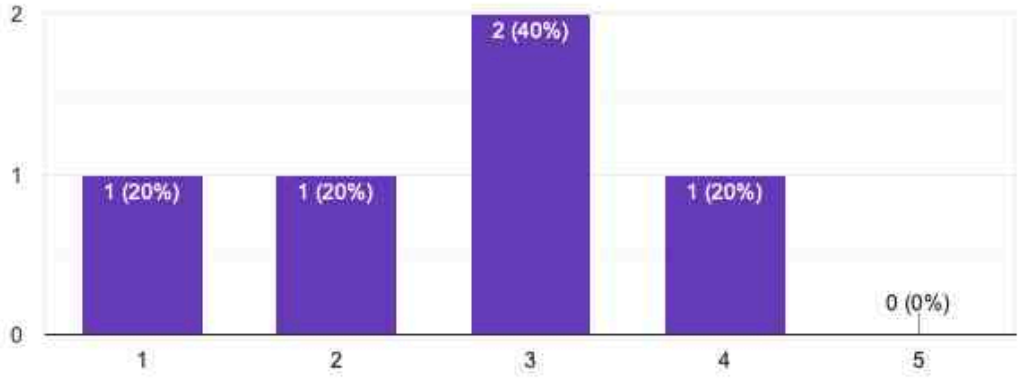
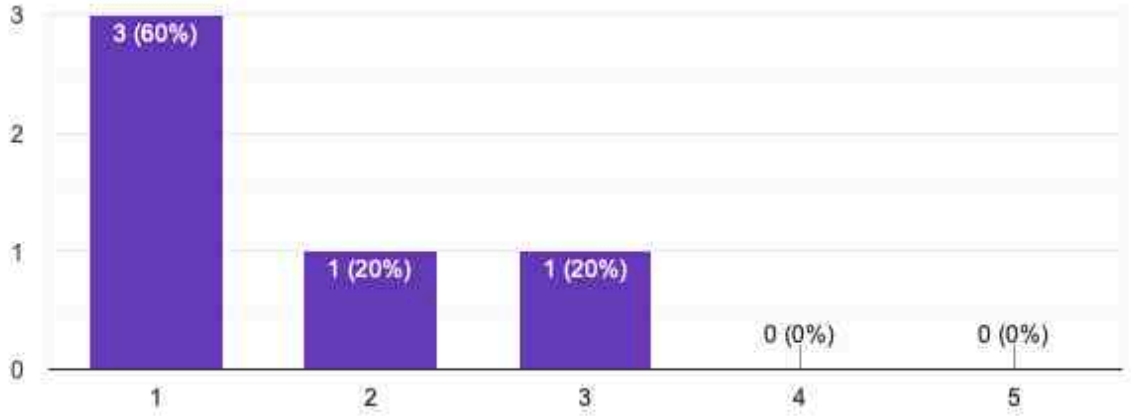
5 responses



Trustworthy vs Unreliable

Copy

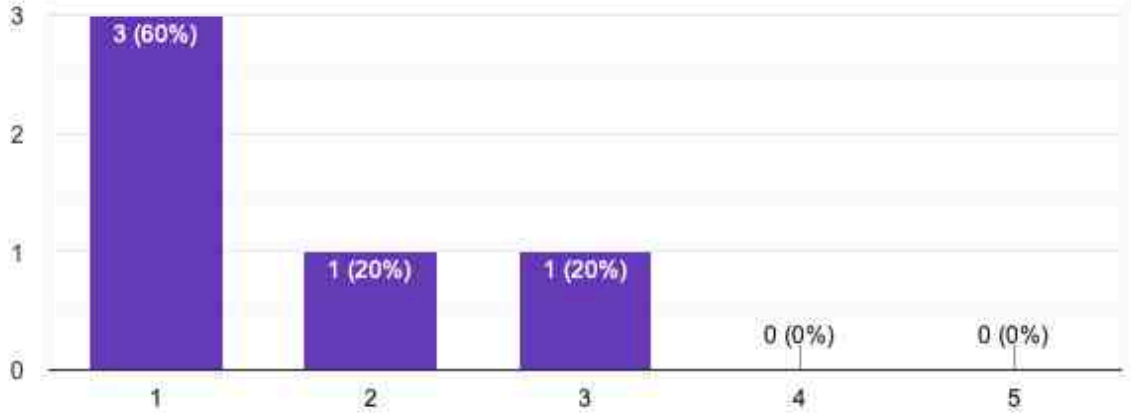
5 responses



Quick vs Slow

Copy

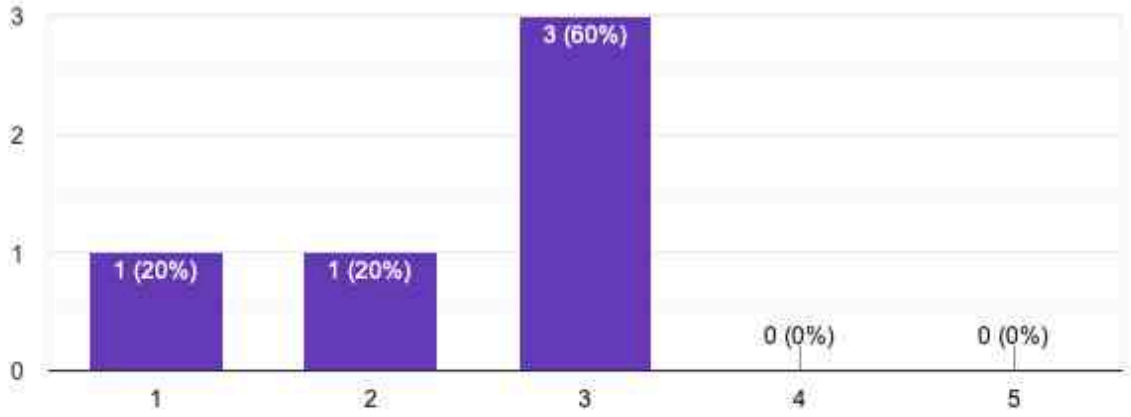
5 responses



Self-explanatory vs Cryptic

Copy

5 responses



Appendix 15: Questions final user test

Final test

Okay to record audio and some video on hands?

REMEMBER TO PHOTOGRAPH AND VIDEO INTERACTION

Sally: Your smart home Ally
being connected to smart home and showing all devices: lights, tv, audio, comfort

if something is changed in app it updates on the device, and vice versa

the device can set alarm clocks and be used without the need for a phone

showing the latest playlists and series you've watched, being able to select which speaker or tv to plat it on

Small device

Först visar jag hur den är tänkt att se ut och dess storlek. Sen ska du få testa att styra ljus med en annan prototyp.

1. vad är ditt första intryck? (HAND OVER SMALL)

2. Vad tycker du om storleken?

3. Hur känns knapparna och att nå till toppen och neråt?

4. Hur känns det att skruva på ratten i handen, eller när den ligger på bordet?

Large device

Förevisa hur man kan välja ljus nertill, rotera, klicka på byta färg, rotera. Berätta om status längst upp, färg och ljus visas i mitten

5. TEST: Välj ljus, justera ljuset i HEM, ändra sen ljus i DINING ROOM (

6. Hur känns det att styra ljusen på detta sätt med knappar och ratt?

7. Andra tankar eller frågor kring denna prototyp?

Tänk dig använda det här i framtiden

Fast i den mindre storleke

Choose on the scale which words best describe the interaction

8. Simple vs Complex

Mark only one oval.

	1	2	3	4	5	
Simple	◯	◯	◯	◯	◯	Complex

9. Familiar vs Unfamiliar

Mark only one oval.

	1	2	3	4	5	
Familiar	◯	◯	◯	◯	◯	Unfamiliar

10. Trustworthy vs Unreliable

Mark only one oval.

	1	2	3	4	5	
Trustworthy	◯	◯	◯	◯	◯	Unreliable

11. Quick vs Slow

Mark only one oval.

	1	2	3	4	5	
Quick	◯	◯	◯	◯	◯	Slow

12. Self-explanatory vs Cryptic

Mark only one oval.

	1	2	3	4	5	
Self-explanatory	◯	◯	◯	◯	◯	Cryptic

13. Comments on scale

14. Tror du produkten kan vara snabbare än telefonen för att styra det mesta i hemmet?

Mark only one oval.

- ◯ Ja
- ◯ Nej
- ◯ Other: _____

15. Tror du produkten kan vara lättare än att använda en telefon med appar?

Mark only one oval.

- Ja
- Nej
- Other: _____

16. Tror du produkten kan vara trevligare att använda? Mer delightful?

Mark only one oval.

- Ja
- Nej
- Other: _____

17. Hade du velat köpa den här? Vad skulle i så fall vara viktigast för dig? (pris, kvalitet, funktioner, annat, design)

_____

_____

_____

_____

_____

18. Tror du att en sådan här produkt hade fått dig att lägga undan telefonen mer när du är hemma?

_____

_____

_____

_____

_____

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