

Kari Stam Faugstad and Bendik Schrøder

# Magic as a Design Approach to Smart Home Interactions and Experiences

Master's thesis in Industrial Design

Supervisor: Trond Are Øritsland

Co-supervisor: Dag Svanæs

June 2023

NTNU  
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## Masteroppgave for Bendik Schrøder og Kari Stam Faugstad

### Metaphor-driven interaction design: Looking to magic for new takes on controlling the smart home

*Metafordrevet interaksjonsdesign: Magi som utgangspunkt for nye retninger for styring av smarthjem*

While smart home products promise convenience in terms of automation, assistance, and remote oversight, a potential drawback is still the way this technology is operated. Three main paradigms for controlling smart home technology dominate the scene today – voice control through virtual assistants, various apps for smartphones and tablets, and an array of configurable smart switches. As we see it, the innovation in the smart home sphere is largely technology-driven, and smart home interactions tend to be disruptive to the home context. To make smart technology more appealing to the general public, we see a need for a different approach to enable aesthetically pleasing, natural, and discreet interactions that fit naturally into the domestic context. Through an explorative project, we want to draw on relevant theory to envision new approaches to smart home control. Relevant theoretical directions might include tangible interactions, embodied and ecological cognition, and metaphor-driven interaction design. We hypothesize that the realm of magic is a promising place to look for such metaphors. Starting with magic, where everything is possible, allows for free thinking about how people would prefer to control their environment. The lore, myths, and legends from past and present cultures are also rich with magical references, and magic's universal presence in the human imagination suggests some fundamental aspect of our nature that might be leveraged to develop more intuitive and pleasurable ways of interacting with technology.

Activities may include:

- A literature review of relevant theory
- Mapping and evaluation of current ways of controlling the smart home
- Using the “magic thing” approach in an ideation workshop context
- Experimental/experiential prototyping
- Feedback sessions in a smart home environment

Oppgaven utføres etter ”Retningslinjer for masteroppgaver i Industriell design”.


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# Abstract

This thesis explores the use of magic as it is portrayed in myths, folklore, and fantasy literature as a perspective from which to design for interactions and experiences in smart homes. The thesis is motivated by a desire to enable aesthetic interactions that fit well into a domestic context. The emotional and engaging nature of magic contrasts the streamlining and optimization of everyday life, which are central selling points of current smart home technology.

The thesis provides an overview of relevant theory related to magic, smart homes, metaphors, and Tangible User Interfaces. In the following design process, the methodological approach was qualitative, explorative, and relied on research through design.

The design project consists of three rounds of exploring different ways of implementing magic in the design process. Firstly, magic was used as a method in co-creative workshops related to magical interactions with light and sound in smart homes. Magic as a method was found to be most effective in completely open tasks that are distanced from how technology is currently operated. Next, animation magic was used as inspiration for physical dialogue with an

intelligent agent in the home. This concretized abstract topics such as limiting an intelligent agent's agency, which enabled discussions with users about living with artificial intelligence. However, there is a risk of instigating uncritical technological optimism by likening artificial intelligence to magic. Finally, magical objects were used as a source of product metaphors. This resulted in a simple, tangible interface that suggests an ambient light atmosphere in the home and facilitates ritualization around the interaction that initiates this atmosphere. Common perceptions of what is magical make conveying metaphors drawn from magic easy. It is found that while magical fascination with a product may fade over time, borrowing aspects from magical experiences could be a valuable starting point for creating enduring aesthetic experiences.

Staying true to magic throughout the process led to a simpler product based on emotional values and experiences, rather than complex functionality and unrestricted flexibility. This is a step away from what characterizes today's smart home technology and shows that magic can contribute to new perspectives in interaction design.

# Sammendrag

Denne oppgaven utforsker bruk av magi slik den er fremstilt i myter, folketro og fantasy-litteratur som utgangspunkt for design for interaksjon og opplevelser i smarthjem. Oppgaven er motivert av et ønske om å tilrettelegge for estetiske interaksjoner som passer godt i hjemlige omgivelser. Det emosjonelle og engasjerende ved magi står i kontrast til effektivitet og strømlinjeforming av dagliglivet, som er sentrale salgspunkter for dagens smarthjemteknologi.

Oppgaven gjør først rede for relevant teori knyttet til magi, smarthjem, metaforer og fysiske brukergrensesnitt. I den påfølgende designprosessen var den metodiske tilnærmingen kvalitativ, utforskende og støttet seg på forskning gjennom design.

Designprosjektet består av tre runder med utforsking av ulike måter å implementere magi i designprosessen. Først ble magi brukt som metode i samskapingsworkshops om magiske interaksjoner med lyd og lys i smarthjem. Her kom det frem at magi som metode er mest effektiv i helt åpne oppgaver som er distansert fra hvordan dagens teknologi styres. Deretter ble animasjonsmagi brukt som inspirasjon for fysisk dialog med en intelligent enhet i hjemmet. Dette konkretiserte abstrakte temaer, som å begrense

handlingsrommet til en intelligent enhet og tilrettelagt for diskusjoner med brukere om kunstig intelligens i hjemmet. Det er imidlertid en fare for å bygge opp under ukritisk teknologioptimisme ved å sammenlikne kunstig intelligens med magi. Til slutt ble magiske objekter brukt som kilde til produktmetaforer. Dette resulterte i et enkelt, fysisk grensesnitt som foreslår en hyggelig stemning ved hjelp av lyssetting i hjemmet, og tilrettelegger for et rituale rundt interaksjonen som initierer denne stemningen. Felles forestillinger om hva som er magisk gjør det lett å formidle metaforer hentet fra magi. Det kommer også frem at selv om den magiske fascinasjonen ved et produkt kan forsvinne over tid, kan det å la seg inspirere av magiske opplevelser være et verdifullt utgangspunkt for å skape varige estetiske opplevelser.

Å være tro til magi gjennom hele prosessen førte til et enklere produkt basert på emosjonelle verdier knyttet til opplevelser, heller enn kompleks funksjonalitet og ubegrenset fleksibilitet. Dette er et steg vekk fra det som preger dagens smarthjemteknologi og viser at magi kan bidra til nye perspektiver i interaksjonsdesign.





# Our Motivation

Up until now, the smart home has been in the hands of early adopters: Those who are fascinated by technology, who enjoy tinkering with new gadgets, and who do not mind ad hoc solutions for making the smart appliances work together as a system. As the field matures, with new, universal protocols being adopted for interoperability among vendors and product categories, the stage is being set for smart homes to reach the average household.

While smart products promise convenience in terms of automation, assistance, and remote oversight, we see a potential drawback with the way we interact with this technology. Three main paradigms for interacting with smart home technology dominate the scene today – voice control through virtual assistants, various apps for smartphones and tablets, and an array of configurable smart switches. Voice assistants require precise commands that the user must formulate before stating them. Using voice control in a social setting is indiscreet and sometimes disruptive to the conversation. Smartphones and tablets are largely multipurpose devices, not dedicated or integrated into the domestic scene. Such devices require direct attention, and noise from other applications tends to distract us: They lack the effortlessness afforded by a simpler, dedicated entity such as a remote or a light switch. Switches, however, are quite inflexible and are limited in their ability to deliver the benefits promised by a smart home.

The promise of convenience has driven important innovation in domestic technology. Indeed, in a well-known TED talk, Hans Rosling pointed to the introduction of the washing machine as a major contributor to equality and economic growth in the 20th century (Rosling, 2010). However,

modern homes are by now quite saturated with convenient solutions. Our homes are more than mere living machines; they are where we wind down, recharge, and connect with our family and friends. When decorating our living rooms, most of us consider more than just ergonomics when choosing an armchair. We also fill our shelves with memorabilia, even though they mostly collect dust. Our homes reflect who we are, and as smart home technology enters this scene, we believe it is necessary with a closer look at how it integrates with the emotional side of domestic life.

As we see it, there is a lack of aesthetically pleasing smart home interactions that fit naturally into the domestic context. Designing interactive systems on technology's terms tends to impede their usability and experiential quality. Starting with magic, however, where everything is possible, allows for free thinking about how people would prefer to control their environment. Magic is in its nature emotional and engaging rather than functional and mechanistic, and seems to have potential as a corrective to the convenience-focus of current smart home technology. The lore, myths, and legends from past and present cultures are also rich with magical references, and magic's universal presence in the human imagination suggests some fundamental aspect of our nature that possibly could be leveraged to develop more intuitive and pleasurable ways of interacting with technology. We also hypothesize that the realm of magic is a promising place to look for metaphors that can inspire new experiences within the smart home.



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# Background

This chapter serves two purposes: it introduces relevant theory that will be used to support design decisions later in the thesis, and it provides an overview of magic's role in the design field. The first section will define the concept of magic and its relevance to design.

The second section will provide an overview of prominent smart home technology, as well as some design examples that provide different takes on smart home interaction.

The third section provides a brief overview of tangible user interfaces (TUIs) and how those can be leveraged to create more aesthetically pleasing interactions, beyond two-dimensional touch screens.

Finally, the fourth section will discuss the relevance of metaphors in design and what to consider when using them.

# 1.1 Magic and design

The concept of magic is deeply ingrained in society and the human psyche (Subbotsky, 2010). It plays a central role in various aspects of culture, such as religion, myths, and folklore and often involves rituals, spells, and supernatural powers. It is also prevalent in contemporary culture, with popular works like J.K. Rowling's Harry Potter, J.R.R. Tolkien's Lord of the Rings, and George Lucas' Star Wars captivating our imagination.

## 1.1.1 What is Magic?

Like other foundational human concepts such as humor and happiness, defining magic and the notion of something being magical proves challenging, primarily due to its intuitive nature. As a starting point, we will examine the dictionary definition. Merriam-Webster provides three definitions of magic:

1. "The use of means (such as charms or spells) believed to have supernatural power over natural forces, or magic rites or incantations."
  2. "An extraordinary power or influence seemingly from a supernatural source, or something that seems to cast a spell: Enchantment"
  3. "The art of producing illusions by sleight of hand."
- (Merriam-Webster, n.d.)

As illustrated, magic refers both to the act of conducting magic – being able to perform magic and wield it to achieve something, and to an external entity, such as a natural force or an enchanted entity.

The third definition, the art of illusion and stage magic, will be of less focus in this thesis. Although design can learn much from stage magic regarding controlling attention, creating anticipation, and building narratives (Tognazzini, 1993), this exploration will emphasize the stories

and principles of magic, rather than how the illusion of magic can be recreated in real life.

The two first definitions of magic's adjective counterpart, *magical*, provide further nuances:

1. "Of, relating to, characterized by, or producing magic"
2. "Produced by or as if by magic" (Merriam-Webster, n.d.)

Here, a distinction is drawn between something that is magical in the sense that it is or produces magic, or that it occurs as a result of a magical action or phenomenon.

The third definition of magical is perhaps the most elusive:

3. "Extremely or extraordinarily pleasant, enjoyable, or exciting"

While this definition certainly relates to magic, it is also used more broadly to describe feelings of wonder and pleasure. We will revisit this definition when examining the relationship between design and magic.

## The Laws of Magic

The psychologist Eugene Subbotsky (2010) provides another perspective on the nature of magic. In his studies of magic and the human mind, he uses three useful concepts; magical thinking, magical reality, and magical laws of causality.

Magical thinking refers to our ability to imagine and contemplate impossible entities or actions. For example, imagining having the ability to levitate or discussing which spell in Harry Potter is the cruelest. This is different from ordinary fantasy, where objects and events adhere to the same physical and causal constraints as they do in the real world. In contrast, magical thinking allows for the suspension of real-world principles.

Subbotsky further distinguishes between two types of magical cognition: magical thinking and magical belief. Magical thinking refers to mental engagement with impossible concepts, while magical belief involves the judgment of whether these concepts are real or not.

How do you classify the impossible?  
According to Subbotsky, there are four types of magical causalities:

1. "The direct effect of consciousness over matter, such as affecting or creating physical objects through the effort of will (mind-over-matter magic)"
  2. "The sudden acquisition of spontaneity by a non-animate physical object (animation magic)"
  3. "A violation of the fundamental laws of object permanence, physical space, and time, such as one physical object inexplicably turning into another physical object in an instant (nonpermanence magic)"
  4. "When certain objects or events affect other objects or events in a nonphysical way, through similarity or contagion (sympathetic magic)"
- (Subbotsky, 2010, p. 5)

These are the laws governing what he refers to as magical realities. These are the spaces we go to when we imagine the impossible, whether that is religious faith, a mythical realm, or a fantastical universe.

In myths, religion, and fantasy, magic is often performed and expressed through shared themes reflecting these four magical causalities. These commonalities are evident in the way supernatural events are depicted, the roles of magical beings, and the symbolic significance of rituals and enchanted objects.

*Mind-over-matter magic* is often associated with gods, supernatural beings, or gifted individuals who possess the ability to manipulate physical objects or manifest desired outcomes through sheer will and a focused mind. For instance, telekinesis, "the force" from Star Wars, and the power of prayer exemplify the direct effect of the mind over physical matter.

*Animation magic* is often expressed through inanimate objects that are given life or consciousness, such as Golems from Jewish mythology, enchanted brooms in European folklore, or the talking animals and furniture in tales like "Beauty and the Beast."

*Non-permanence magic* involves shape-shifting deities and creatures, miraculous transformations, and teleportation, all of which defy the conventional laws of object permanence, physical space, and time. Examples include the metamorphoses of gods in Greek mythology, Jesus' resurrection in Christianity, and the ability to apparate in the Harry Potter universe.

*Sympathetic magic* is often manifested through rituals, talismans, or symbolic actions that are believed to influence events or outcomes. This could be because of resemblance, or because of lasting effects, such as a lingering curse or blessing. This type of magic can be observed in the practice of voodoo, the use of religious relics, and Sauron's power over "The One Ring" in "Lord of the Rings".

### **What do we imagine in worlds where everything is possible?**

David Rose, a designer, entrepreneur, and MIT lecturer argues for looking to magic to create more meaningful technology. He sees enchanted objects, featured in our cultural history, as expressions of fundamental human drives. His book *Enchanted Objects* focuses on six desires: omniscience, telepathy, safekeeping, immortality, teleportation, and expression (Rose, 2014).

Our desire for omniscience, wanting to know everything, and longing to predict the future, is reflected in magical objects like the all-knowing crystal ball often used by fortune tellers. Telepathy, the desire to intimately connect with others' thoughts, is exemplified by enchanted objects such as the Pensieve in the Harry Potter series, which enables access to stored memories. Safekeeping, seeking protection, is embodied as protective amulets and talismans found in various cultures. Immortality, the pursuit of enduring health, can be found in the alchemist's search for the Philosopher's Stone, believed to grant eternal life. Teleportation, the longing for unrestricted movement, is reflected in the closet in C.S. Lewis's *The Chronicles of Narnia*, which transports you from our world to Narnia. Lastly, expression, the wish to create and share, is enabled by mythical objects like the magic brush in Chinese folklore, which brings to life anything it paints.

Rose's view of enchanted objects in stories and myths as channels to our desires led him to derive direct inspiration from their design to envision new and better user experiences. His inspiration is rooted in their physicality: the clear analogies of

use, the glanceability that physical things provide, and the emotional connections we form to long-lasting physical products. He contrasts this with our screen-centric reality, which he refers to as the terminal world, dominated by glass slabs.

Rose's perspective on enchanted objects is one of the multiple ways magic has been leveraged in design. We will examine this further in the next section.

## **1.1.2 Magic's Role in The Design Discipline**

Science fiction writer Arthur C. Clarke's (1968) famously stated that "any sufficiently advanced technology is indistinguishable from magic". His statement underscores the blurred line between cutting-edge technology and the mystical realm: When technology reaches a level of sophistication beyond our current understanding, it can evoke awe and wonder similar to the notion of magic.

Throughout history, there has been a reciprocal relationship between these two domains. Magic has often been a catalyst for the development of science and technology. One example is alchemy, an ancient practice that sought to transform base metals into gold and discover the elixir of life. Even though it was steeped in mystical beliefs, alchemy laid the groundwork for modern chemistry, contributing valuable knowledge and experimental techniques (Multhauf & Gilbert, 2023).

Conversely, technology has been used to create illusions of magic, from ancient practices simulating the presence of gods or communication with the dead (Sharkey & Sharkey, 2006) to modern-day illusionists who use cutting-edge technology to perform seemingly magical feats.



An interesting perspective on Clarke's point about the relationship between technology and magic is provided by Rasmussen (2013) about magical realities in interaction design. To challenge the view that magic holds little relevance in the realm of design, she showed that magical properties can be present in the interaction with designed artifacts, even when their creators did not intend to incorporate such qualities. She organized a series of design projects in accordance with Subbotky's laws of magical causality, illustrating how modern technologies, such as sensors and wireless communication, provide the means to construct artificial magical realities. For instance, she draws a parallel from Brain-Computer interfaces powered by EEG (electroencephalography) to mind-over-magic, and from gravity-defying TUIs powered by air pressure or magnetic levitation to nonpermanence magic.

As demonstrated by both Rose and Rasmussen, the realm of magic can serve as a rich source of inspiration for various aspects of the design process. We will look closer at four areas where magic has influenced design:

1. Magic as a source of metaphors
2. Magic as inspiration for new design directions
3. The magical feeling: Magic as an aesthetic quality
4. Magic as a design method

### **Magic as a source of metaphors**

One way design researchers have engaged with magic is through the search for alternative metaphors. A metaphor is a way of describing an object or action that is not literally true but helps to explain or illustrate an idea by drawing comparisons. They are often used in design to create original and aesthetic design solutions by converting abstract ideas into concrete product properties. (Cila, 2013). Metaphors are further discussed in Chapter 1.4.

As part of the first TUI wave at the turn of the millennium, Dag Svanæs and William Verplank

were investigating possible sources of metaphors for tangible interfaces. By looking at religion, folklore, and paranormal phenomena from our cultural consciousness, they identified four magical aspects that might be leveraged as metaphors, which bear resemblance to Subbotky's laws of magical causality, as well as Rose's fundamental human drives: telepathy, relics, the holistic universe, and magic through resemblance. Digital technology has come a long way since it was published, which is reflected in the design concepts brought up in the article. Nevertheless, their hypothesis about magic was part of the inspiration for this thesis:

*"The hypothesis is that users would find systems with 'magical' behavior easy to understand because it behaved according to their tacit expectations of magic."*

(Svanæs and Verplank, 2000, p.127)

### **Magic as inspiration for new design directions**

In 2015, at the Smashing Conference, Josh Clark delivered a lecture on "Magical UX and the Internet of Things" which echoes the vision of David Rose. Clark proposed that looking to magic for new ways of interacting with technology could make us happier and more present in the world (Smashing Magazine, 2015). He proposed a shift in interaction design, where digital interactions are pushed off screens and integrated into our objects and spaces. He explains this need by referring to our current, paradoxical relationship with technology:

*"The more we try to use technology to build a stronger tie to the physical world, or even more to our physical selves, the more we shove a screen in between us and the world. These things are making us so much more powerful but also make us disconnected in important ways. Phones wedge themselves between us and our surroundings. So even in traditionally social situations, we're heads down in our screens, isolated from the people we love and places that we care about."*

(Clark, 2015, 12:51)

Furthermore, to avoid designing things from a technological perspective, and rather from a human one, he states that designers instead should ask, “What if this thing was magical?” He believes this will lead to designs that honor a thing’s essential “thingness,” making them more of what they are, rather than arbitrarily augmented gadgets.

Inspired by the intuitive and decisive movements of wanded wizards, he advocated for interactions that actively capture our intent, as opposed to passive listening. Clark illustrated this idea with his “Happy Together” concept, an interaction concept for switching speakers from a portable device to a stationary one (Image 1.1). Instead of switching outputs through a conventional interface, users could simply tap their phone on the stationary speaker.



Image 1.1: “Happy Together” (Clark, 2015)

In sum, he proposes that we look to the “centuries of UX ideas” deriving from magical legends, stories, and myths to build more meaningful experiences in the Internet of Things era.

### Haunted design

Annett et al. (2016) looked to supernatural and paranormal phenomena to see whether they could help fulfill ubiquitous computing pioneer Mark Weiser’s vision for the future of computing: “the highest ideal [should be] to make a computer so embedded, so fitting, so natural, that we use it without even thinking about it” (Weiser, 1999,

as phrased by Annett et al., 2016). The authors argued that the main challenge is to effectively integrate interactions within the context of use. They used the metaphor of “haunted design” to propose new modalities for ambient data display in the home context. Their argument for stronger integration is emotionally and aesthetically motivated:

*“We fear that if designers do not break away from their reliance on conventional designs, spaces will eventually become completely void of the elements that evoke personality, tangibility, and memory.”*  
(Annett et al., 2016, p. 1328)

By combining research on people’s use and interior preferences with analysis of various paranormal and supernatural phenomena, they present four qualities of inspiration: *the role of tangibility, familiarity, intensity, and shareability*. To test these qualities, they prototyped five design concepts in a simulated living room. The concepts were inspired by various otherworldly sources, including séances and the movements of ghosts. The prototypes exhibit a wide variety of aesthetic expressions and sensory stimuli, including a taxidermy moose with moving antlers, writing that appears on a foggy mirror and directional speakers that discreetly whisper private messages. While their design concepts are highly experimental, they illustrate how looking to magic can expand the design field’s scope of how digital information could be expressed.

### Harry potter as design inspiration

In their article *Humdrum Magic: Design Explorations into the Magic of Everyday Life*, Eggen & Eggen (2012) argue that J.K. Rowling was ahead of her time with her Harry Potter universe. They suggest that artifacts from the book series can serve as references and inspiration for three branches of the design discipline: designing for experiences, ambient intelligence, and calm technology.

Firstly, Eggen & Eggen argue that we can only design for experiences – facilitate them, but not

design the experiences themselves. Designing products that successfully facilitate experiences should focus more on the moments and stories that result from interacting with the product, rather than looking at the product interaction in isolation. They bring up “Bertie Bott’s Every Flavour Beans” from *Harry Potter and the Philosopher’s Stone* as an example: While some of the beans taste horrible (like vomit, for example), the surprise element of not knowing what a bean will taste like inspires personal stories and social experiences.

Secondly, ambient intelligence refers to environments that are embedded with sensors, microprocessors, and software that make them responsive and sensitive to human presence. These “smart” environments aim to facilitate our lives by adjusting to our needs and preferences in an unobtrusive and seamless manner, enhancing user-friendliness, efficiency, and human interactions (Cook et al., 2009). Eggen & Eggen liken true ambient intelligence to a magical experience. As an example of an ambient intelligent device that targets human needs well, they bring up the Whereabouts clock from the Weasley family’s home in *Harry Potter*. The clock has multiple hands, one for each family member, indicating their location in the world, as well as more abstract states such as being in mortal peril. Its physical interface affords glanceability, and its grandfather clock design makes it well-suited to the cluttered and homely interior of the Weasley home.

Thirdly, calm technology refers to technology that integrates seamlessly into users’ lives by providing necessary information without demanding continuous attention. It operates mostly in the periphery and offers information as needed without being overwhelming. In a world where an ever-increasing number of devices demand our attention, calm technology aims to rethink how the information we surround ourselves with is presented (Weiser & Brown, 1996). Eggen & Eggen reference several instances from J.K. Rowling’s universe as examples of

calm and peripheral information presentation. One notable example is the enchanted ceiling of Hogwarts’ Great Hall. The ceiling is enchanted to reflect the weather and sky outside, resulting in a decorative and informative addition to the room that does not demand to be the center of attention of its visitors.



Image 1.2: Bang & Olufsen Overture/Beosound 3200 (Bang & Olufsen, n.d.)

### **The magical feeling: Magic as an aesthetic quality**

As previously mentioned, the word magical is defined as something ‘extremely or extraordinarily pleasant, enjoyable, or exciting’ (Merriam-Webster, n.d.). The term ‘magical’ is also sometimes used to describe certain feelings evoked during interaction with designed artifacts (Rasmussen, 2013; Diefenbach & Ullrich, 2015).

To capture this magic in tangible products, Bang & Olufsen, a high-end consumer electronics company, has taken a keen interest in infusing their product with ‘a touch of magic’ (de Jongh Hepworth, 2007). At the time an interaction designer at Bang & Olufsen, de Jongh Hepworth investigated what constitutes a magical experience when interacting with a product.

By discussing and brainstorming magical product experiences with a concept developer at the company, he found four recurring elements: surprise (something unexpected), unordinary (something that stands out from previous experiences), unnatural (something that seems impossible), and exciting (something that builds anticipation). These elements provide a framework to examine and understand how Bang & Olufsen's products are designed to elicit 'magical' experiences.

For instance, Image 1.2 shows the Beosound Overture CD player, which doors slide open in a smooth, easing motion when someone approaches, a detail facilitated by an intricate wire mechanism (Beosound history, n.d.).



Image 1.3: Bang & Olufsen Harmony (Bang & Olufsen, n.d.)

It is a welcoming gesture, resolving a puzzling design in a surprising way, as the design does not reveal a clear way to open the doors. The B&O television sets, on the other hand, seem to be built with anticipation in mind. In its turned-off state, The Beovision Harmony television (Image 1.3) is covered by its speakers. When turned on, however, the speakers will rotate in a butterfly-like manner to uncover the screen, which slowly ascends from the ground (Beovision Harmony, n.d.). Combined with the company's untraditional focus on moving parts (bringing into mind Subbotky's principle of animation magic), the 'unordinary' element comes to life in Bang & Olufsen's unusual

choice of materials, favoring wood and aluminum over the typical plastics that dominate the television market.

The carefully choreographed movements of the Harmony TV span nearly 18 seconds, a feature that may seem excessive from a purely functional perspective. Despite the superior audio and visual quality, these additional features significantly inflate the product's price; the Harmony currently retails at \$34 350 (Beovision Harmony, n.d.). This implies that there is an inherent value in these theatrical elements, even within the consumer electronics market where speed and convenience are typically front and center.

Do these kinds of magical experiences last? In his magical design experiments, de Jongh Hepworth (2007) found that the magical experience resulting from being surprised by a simple prototype faded quickly. When testing a more elaborate music selection prototype, however, he found that the dynamics of interactivity sustain the magical feeling. This notion is mirrored by Rasmussen:

*"Another point, which can be raised when introducing a technologically constructed magical reality, is whether the magic of the first encounter can last? What happens to the experience, when going beyond the initial experience of surprise, fear, wonder, or delight, when the element of surprise is lost and the experience become familiar? And does the sense of magic get jaded when we figure out how the trick works?"*

(Rasmussen, 2013, p. 128)

It is clear that a magical surprise alone does not necessarily make a product valuable. However, as seen in the examples of Bang & Olufsen, the focus on adding a touch of magic has yielded products with distinctively aesthetic interactions. To understand the aesthetics of interaction, Lenz et al. (2013) emphasize the importance of understanding the connection between the "how" and "why" levels, or between the perceptual and action attributes of an interaction

and the emerging experience. They argue that it is impossible to create an interaction without considering the experience and meaning that it will create.

Similarly, designing for experience requires acknowledging the concrete interaction that induces the experience in question. The researchers found that certain attributes can create specific experiences. For example, a “fast” interaction may suggest that the action is unimportant and only the goal is significant, while a “slow” interaction may imply that the action holds importance and must be executed with care. Therefore, they argue, designers need to design interactions that align with the experiences they want to create to effectively shape the user’s experience. Lenz et al. (2013) exemplifies this with a design concept for an engagement ring jewelry box. The gravity of the why level of the interaction – asking if someone wants to marry you, should be reflected in the interaction (the how), which therefore aimed to be slow, stepwise, delayed, precise, gentle, and targeted. The solution to this was a lid that needs to be delicately unscrewed. A song plays during the unscrewing, which fades out when the lid comes off and the ring is revealed.

This connection between the why and the how level is also present in magical interactions found both in old legends and popular culture. Harry Potter offers an example, where the intent or gesture behind certain spells must align with the desired outcome, such as the Patronus charm requiring a happy thought, or the lethal Avada Kedavra and torturous Crucio spells, which only work if the spell caster has a genuine intent to harm or kill. Another instance is the Arthurian legend, where the victorious extraction of Excalibur (the how) corresponds to the destiny of becoming Britain’s rightful king (the why). The action embodies hope, effort, and success, and is reflected in Arthur’s triumphant stance when he pulls the sword from the stone.

### **Magic as a creative design method**

In 2000, a group of researchers from the University of Helsinki sought to find out what needs a future smart, internet-connected mobile device could fulfill (Iacucci et al., 2000). Neither the technology nor the services for such a device existed, so the researchers resorted to role play and scenario enactment to envision future situations of use. In one activity, a user carried around a simple “magic” mock-up of a future device in their daily activities. They were encouraged to envision and act out scenarios where this magic device could be useful. In the example given in the paper, one participant used the magic device to imagine scenarios where it could provide music in different lab rooms, offer quick translation services, allow him to check news during his experiments, and enable him to edit a Word document on the go. This “magic thing” as they term it in the paper has since been framed as a creative design method (Wilson, 2012).

Magic is also used in the context of human-centered design as a way to boost creativity in participatory workshop settings. Ylipulli et al. (2017) leveraged the metaphor of magic in a participatory design workshop about new library experiences. They found that magic helped the participants be future-oriented in their ideation and freed them from the perceived constraints of contemporary technology.

In addition to letting the idea of “enchanted objects” inform his own design practice, David Rose also leverages this concept to help his students ideate around the design of tangible technology (Rose, 2014). In one activity, his students are asked to attach a piece of masking tape to any object they believe could provide an enchanted service. They then brainstorm potential interfaces, sensors, or displays that could be incorporated into the object. This exercise prompts students to consider a range of questions, such as the balance between distraction and value, the effort required to interact with the object, whether the interface mimics the natural world, and the object’s agency and personality.

**Conclusion**


The concept of magic has an enduring appeal, with a presence in both ancient legends and popular culture. It can be seen as a portal to our deepest desires, help us understand new technology, and serve as inspiration for new user experiences. In contemporary design research, magic has served as a rich source of inspiration for various aspects of the design process. The concept of magic can be connected to branches of design attempting to rethink our connection with digital technology, and products that have value beyond their convenience. Magic can be a source of new metaphors, help illustrate the concept of interaction aesthetics, and serve as a design method to free people from the constraints of current technology, inspiring innovation and fostering creativity.

# 1.2 The Smart Home

A smart home refers to a domestic Internet of Things (IoT) system that allows physical devices to be connected and interact with each other (Alaa et al., 2017). IoT refers to a network of objects with sensors, software, network connectivity, and electronics that can collect and exchange data without human intervention (Xia et al., 2012). These devices, which are often called smart devices, range from appliances, lighting, heating, and air conditioning to TVs, computers, and security systems (Alaa et al., 2017).

Key properties of a smart home include automation, remote control and oversight, and interoperability (Stojkoska et al., 2017). Automation allows predefined sequences of actions to be executed based on specific triggers, such as time or specified events. Remote control and oversight enable devices to be managed from anywhere, typically with a smartphone app. Virtual assistants, residing both in smartphones and smart speakers, provide users with assistance and enable voice-based home control.

Interoperability is a critical aspect of a smart home, referring to the ability of different smart devices to communicate and work with each other. This interconnectedness enables centralized control of devices and allows automated actions for one device to be triggered by input from another, as well as the use of devices from multiple vendors together. However, in practice, software incompatibilities and lock-in mechanisms from certain providers can hinder the seamless cooperation and integration of different devices, making it more complicated than it may seem (Newman, 2018). New protocols, namely Matter and Thread, aspire to remove these barriers (CSA-IOT, n.d.).

 An overview of the major smart home platforms can be found in Appendix A.

## 1.2.1 Relevant Technologies

**IFTTT (If This Then That) and Home Assistant** are two notable automation platforms. IFTTT uses simple rule-based automation and supports a wide array of data sources, making it easy for beginners to set up automations between different services and devices (IFTT, 2023). On the other hand, Home Assistant is an open-source platform that offers extensive customization options and wide device support (Home Assistant, 2023). It's a good option for enthusiasts who don't mind a steeper learning curve to achieve a highly personalized smart home.

**Zigbee and Z-Wave:** While not smart home platforms themselves, Zigbee and Z-Wave are important wireless communication standards used by many smart home devices. While both protocols support mesh networking, allowing devices to relay messages for each other, Zigbee often supports a larger number of devices. However, both protocols are aimed at low-power, low-data rate applications with a focus on network stability and reliability. (Zigbee, 2023; Z-Wave, 2023)

**Matter and Thread:** Matter, formerly known as Project CHIP (Connected Home over IP), and Thread are two pivotal developments in the smart home industry (Matter, 2023). Matter is an open-source, royalty-free standard launched by the Connectivity Standards Alliance, with backing from major tech companies like Apple, Google, and Amazon. It aims to enhance compatibility and security among smart home devices, making it easier for consumers to integrate and control devices from various manufacturers. On the other hand, Thread is a low-power, wireless mesh networking protocol that securely connects devices in the home. It enables devices to connect directly to each other and the Internet, with a design focus on security, reliability, and low power requirements (Thread, 2023).

This makes it ideal for battery-powered devices, and key products like Apple's HomePod mini already serve as Thread border routers, establishing Thread networks for other compatible devices.

## 1.2.2 Interesting Smart Home Design Examples

As inspiration for our following process, we have gathered some different smart home projects that have inspired us in different ways. What they all have in common is that they provide fresh takes on controlling the smart home, challenging the aesthetic we usually associate with smart home products.

### **Layer x Deutsche Telekom: Connectivity**

Showcased at Salone del Mobile 2022 in Milan, Benjamin Hubert of the design studio LAYER and Deutsche Telekom Design collaborated on a concept with a different perspective on the look and feel of smart home products (Deutsche Telekom AG, n.d.). The series of product prototypes (Image 1.4) are soft and homely in their form factor and material palette and challenge the idea that mundane items such as routers need to be stowed away.

### **Memodo: Smart home control with personal tokens**

Gabor Balint has proposed the Memodo concept as a way to challenge the smartphone's role as the central point for triggering smart home actions (Balint, n.d.). Instead, his concept suggests controlling the smart home using personal objects, which he calls totems. These totems can be any small item that fits into the bowl embedded in the product (Image 1.5). A previously programmed sequence will be executed by placing an object in the bowl, such as a change in room lighting or more elaborate automations, like a morning routine. Balint argues that assigning commands to personal objects will make smart home control accessible to more user groups, such as children and elderly with low technology competence. He also looks at it from an emotional perspective, suggesting that totems can foster stronger emotional bonds than a digital interface.





Image 1.4: The product series of the Connectivity concept. (Layer Design Studio, 2018)



Image 1.5: The Memodo project (Balint, n.d.)

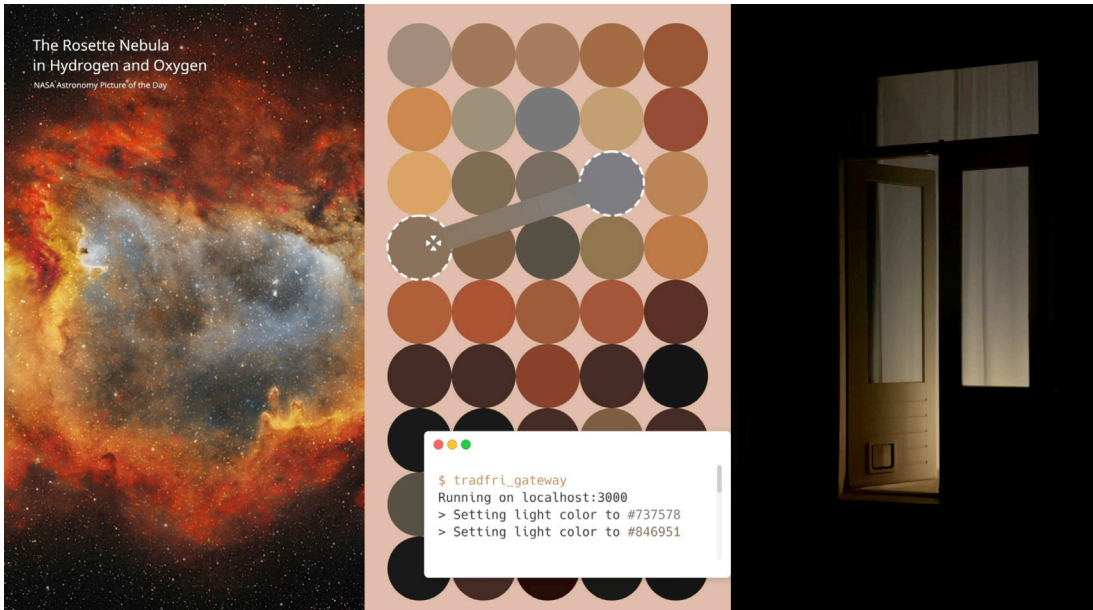


Image 1.6: One of Bakken & Bæck's prototypes for IKEA's Everyday Experiments. (IKEA & Bakken & Bæck, n.d)

### Everyday Home experiments: Bakken & Bæck for IKEA

As part of IKEA's Everyday Experiments, where various designers have been asked to envision how new technology will change domestic life (SPACE10 & IKEA, n.d), the design agency Bakken & Bæck made small functional prototypes to connect IKEA's smart home products with external data in aesthetic ways (Bakken & Bæck, n.d.). For instance, they made a prototype that uses NASA's picture of the day to set the light colors of the room's lamps (Image 1.6). The colors change as a new sample is pulled from the image. We find it interesting how they built these examples using technology many have at home (the IKEA Trådfri hub and light bulbs), showing how the smart home affords new experiences without needing new gear.

### Using smart home technology to envision new mental models around light and energy consumption

With Lumi, an energy orb that lives inside a lantern (Image 1.7), this project explores how one would interact with energy if it were a discrete entity (Schröder et al., 2023). Similar in principle to Dumbledore's Deluminator from the Harry Potter series, this lantern can transfer an energy ball to a lamp, recall it back to the lantern, and then transfer it to another lamp. The combination of light animation, sound, and pointing gestures results in an empowering and magical interaction, which is interesting as the product restricts the user in how they control their lights.



Image 1.7: The Lumi lantern. (Onink / Liveshots Photography, 2022)



Image 1.8: The Mui Board. (Mui Lab, n.d)

### **A calm take on central smart home control**

The Mui board is an innovative and aesthetic take on a versatile smart home control device (Mui Lab, n.d). Inspired by calm technology, the board only displays graphics when in use. When inactive, it only appears as a regular wooden plank mounted on the wall (Image 1.8). The board can be operated through touch or via Amazon Alexa.

Alexa commands can be delivered via voice and by hand-written commands on the board. Mui envisions placing these boards in every room to bridge the versatility of digital interfaces with the unobtrusive and discreet advantage of light switches.

## 1.3 Beyond the Screen: TUI and Embodied Interaction

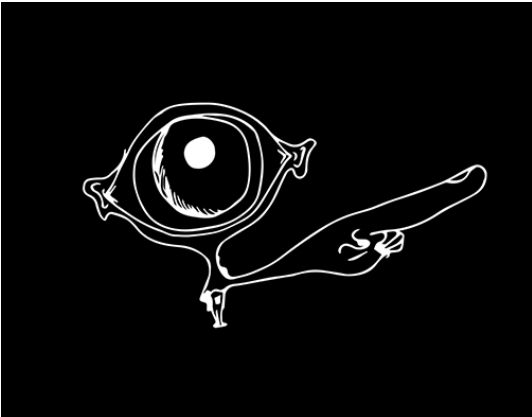


Image 1.9: The Smartphone Homunculus  
(Gershon & Nan, n.d.)

Tangible User Interfaces (TUIs) are interfaces where physical objects are used to represent digital data in Human-Computer Interactions (HCIs), as opposed to graphical user interfaces (GUIs). The concept of TUIs can be traced back to the work of Hiroshi Ishii and his students in the early 1990s on “tangible bits” (Ishii & Ullmer, 1997). This approach to interface design aims to utilize our innate ability to understand and interact with the physical world, leveraging our natural spatial reasoning and motor skills to create more intuitive user experiences. The fact that TUIs exist in the physical world allows us to create physical constraints for what users can do in an interaction, as well as make use of physical affordances to guide the user (Shaer & Hornecker, 2009). The Marble answering machine, designed by Durrell Bishop, is an example where physical affordances and people’s everyday knowledge is used to inform the mode of interaction (Abrams, 1999).

Building on the work on Tangible User Interfaces, Hornecker and Burr (2006) elaborates on the range of human skills that can be utilized for interactions with TUIs. They introduced the term “tangible interaction”, where the emphasis lies on the expressiveness and meaning of bodily movement and less on the physical interface or the data being manipulated.

The concept of embodiment is related to tangible interaction and TUI, which originates in the philosophical school of Phenomenology. In this field, “being-in-the-world” is a central concept that emphasizes that we are not detached observers of the world, but rather that our physical presence plays a fundamental role in how we experience and understand the world (Heidegger, 1962). Building upon this idea, Paul Dourish introduced “embodied interaction” where skilled, engaged interaction is used in HCI (Dourish, 2001).

Tangible and embodied interaction are intertwined and share a common essence: that technology and digital information should be brought into the physical world so that we can interact with it in a natural way. In “Touching the Materialized” Van Campenhout and his colleagues claims that touch screens come from a dematerialization process that causes a loss of physical richness. Interaction with touch screens is limited to buttons or simple gestures on a display, appealing to our cognitive skills rather than our bodies’ perceptual-motor abilities (Van Campenhout et al., 2016). Gerson and Nan at MIT Media Lab illustrated this sparsity with the “smartphone homunculus” (Image 1.9).

It shows how humans would look if our bodies were built for spending most of the day interacting with a two-dimensional touch screen:

*"The smartphone homunculus is how we imagine we, and probably you, look like today. He spends his days looking at a 2-dimensional glass display, probably between 4-inches and 14-inches across. That's why he only needs that one eye. No need for stereo vision. He interacts with this display using his index finger (and occasionally one or two other fingers, when a snazzy multi-touch app supports it), and sometimes his tiny ears take auditory cues ("turn left", "turn right") from his navigation app"* (Gershon, & Nan, n.d.)

Van Campenhout and his colleagues acknowledge the benefits of the flexibility that touch screens offer. Rather than proposing that all interfaces should be physical, they suggest a "third stand" as a design approach that balances the integration of the physical and digital. As opposed to touch screens that are suited for doing multiple tasks, they suggest that physical and digital integration can be optimally balanced in products that are dedicated to one main task. Designing around a specific task and its associated interaction allows for greater incorporation of physical richness (Van Campenhout, et al., 2016). Furthermore, they propose embodiment beyond pragmatic arguments related to ease-of-use (utilizing physical affordances and our natural abilities to interact with the tangible world) and rather propose embodiment from a hedonic perspective - for creating pleasurable interactions (Van Campenhout, et al., 2019).

## 1.4 Metaphors

A metaphor is a figure of speech that describes an object or action in a way that is not true in a literal sense but helps to explain or illustrate an idea by drawing comparisons (Cila, 2013). Metaphors are pervasive in human language and cognition, allowing us to conceptualize abstract or complex concepts through more familiar and concrete experiences. By mapping one domain of knowledge onto another, metaphors enable us to understand and communicate ideas more effectively (Cila, 2013).

Metaphors play a vital role in human language and cognition, as they help us understand and express complex or abstract ideas by relating them to more familiar experiences. George Lakoff and Mark Johnson's seminal work, "Metaphors We Live By" (1980), introduced the concept of conceptual metaphors as a central aspect of human thought, language, and culture. They emphasize that metaphors are not just linguistic expressions or rhetorical devices, but rather integral to the way we think, reason, and make sense of the world. They argue that our everyday language is filled with metaphorical expressions that reveal the underlying conceptual metaphors that structure our thoughts.

An example is how we describe time. Phrases such as "saving time", "spending time", and "wasting time" reflect the conceptual metaphor of time as a valuable and limited resource. Similarly, we speak of life as a journey along a path, seen in expressions such as "the road of life", "reaching a milestone", or "coming to a fork in the road."

Embodied metaphors, a subset of the broader category of conceptual metaphors identified by Lakoff and Johnson, draw on our bodily experiences to structure our understanding of abstract concepts. Embodied metaphors demonstrate how our physical experiences

influence our cognitive processes, which is a core principle of embodied cognition (Wilson, 2002). For example, the embodied metaphor "up is more, down is less" refers to our spatial experience of verticality. Another example is how forward represents progress, while backward signifies regression, expressed through phrases like "taking a step forward" or "moving backward".

### Metaphors in design

In addition to such metaphorical expressions that help us make sense of the world, metaphors play a significant role in shaping how we perceive and interact with products, interfaces, and environments. In the design field, metaphors are used to create original and aesthetic design solutions that communicate functional, social, psychological, and cultural meaning to users by converting abstract ideas into concrete product properties (Cila, 2013). For example, in the early days of graphical user interfaces, the desktop metaphor was introduced to help users understand the organization and manipulation of digital files and folders by drawing parallels to their real-world counterparts (Blackwell, 2006).

Metaphors are also commonly used in the design of physical products. The concept of a product metaphor is the same as linguistic metaphors; to transfer properties from source to target, to make the target inherit a specific meaning from the source. Product metaphors involve projecting selected physical characteristics, such as form, sound, movement, and smell, from a source onto the final product. What separates product metaphors from linguistic metaphors is that the designer cannot simply state that their product resembles something else; they have to physically make it resemble something else (Hekkert & Cila, 2015).

Prior to making it resemble the source, however, designers must carefully select a source that inherits the meaning they have in mind. To make sure the source communicates its meaning as clearly as possible, the potential sources should be narrowed down to the significant examples of their category (Glucksberg & Haught, 2006). This is called metaphor salience. The most salient property of the source should be the meaning that the designer wants to convey. For example, salient examples of safety and comfort could be a nest, cocoon, or harbor. However, a cocoon could also be the symbol of isolation, so the meaning of safety and comfort might not be the one that is interpreted.

Furthermore, the relationship between the target and the source should be considered. If the source and the target have some similarities, there is a higher potential for building meaningful relations between the two (Cila, 2013). However, to avoid dull and uninteresting metaphors, they should not be too similar, as the metaphor may appear obvious and pre-existent (Ortony, 1979; Tourangeau & Sternberg, 1982; Forceville, 2012). Lastly, Hekkert & Cila (2015) suggest that designers should choose a source that aligns with their intentions and proposes two main intentions designers may have for utilizing metaphors: pragmatic intentions, where the goal is to make products and interactions more easily understandable, or experiential intentions which aim to promote emotional and meaningful experiences.

Once the source is found, properties related to the desired meaning need to be mapped to the target object. These cues should include the most essential properties of the source, to make sure that the reference is understandable (Hekkert & Cila, 2015). The mapping can either be done by transferring properties directly to the target, or by capturing and abstracting the essence of the object (Helms et al., 2009). The first method entails a literal mapping of properties, like giving a chair the structure and shape to resemble a birds nest to represent comfort and safety.

It could also be done more elaborately, by infusing the target with the "essence" of the source, providing a more abstract connection between the two, like making a round, deep and soft chair that give the feeling of comfort and safety that a birds nest would hold.

Although the designer can successfully map the source to the object, they cannot control how the result is interpreted by the user. The user might overlook the metaphor completely, or they may detect the metaphor, but not understand the meaning intended by the designer. This is less likely when employing a source that relies on universal knowledge and experiences (Hekkert & Cila, 2015). Even if the metaphor is understood, it may not be appreciated by the user. A metaphor should balance clarity and interestingness to be effective and aesthetically pleasing. (Cila et al., 2014). The metaphor works if the user can identify the source and the intended meaning. However, what makes it interesting is the originality of the idea and the nuance of the mapping. (Hekkert & Cila, 2015)

# 1.5 Summary

## **Magic**

Firstly, magic refers to the act of conducting magic or an enchanted entity. As an adjective, 'magical' is something extraordinarily pleasant, enjoyable, or exciting. In myths, religion, and fantasy, magic is often performed and expressed through shared themes and motifs reflecting four magical causalities: mind-over-matter magic, animation magic, non-permanence magic, and sympathetic magic.

Four ways magic has inspired design magic stands out. Firstly, magic can serve as inspiration for new design directions, as illustrated by David Rose and his enchanted objects. Secondly, magic can function as a method in the design process by freeing people from the perceived constraints of contemporary technology, such as in the "magic thing" method. Thirdly, magic can be a source of metaphors. Lastly, magic inspires design in its aesthetic qualities, as several products from Bang & Olufsen show by providing delight beyond the magic of the first encounter.

## **The Smart Home**

Following the definition of magic and its relevance to design, we introduced contemporary smart home technology. In short, key properties of a smart home include automation, remote control and oversight, and interoperability. Five design projects which challenge the aesthetic we usually associate with smart home products are introduced. They feature different materials, new interaction modalities, and ways of leveraging existing smart home technology for new experiences in the home.

## **Tangible user interfaces and embodiment**

After introducing the smart home, we gave a brief overview of Tangible User Interfaces (TUIs), and some of the advantages they propose. Interaction with touch screens is limited to buttons or simple gestures on a display, appealing to our cognitive skills rather than our bodies' perceptual-motor abilities. Conversely, TUIs utilize our innate ability to understand and interact with the physical world, leveraging our natural spatial reasoning and motor skills to create more intuitive user experiences. In addition to pragmatic arguments related to ease of use, embodying interactions by bringing them into the physical world is suggested to have value from a hedonic perspective: that embodiment can create more pleasurable interactions.

## **Metaphors in design**

Lastly, we discussed the relevance of metaphors in design and what to consider when using them. Metaphors are figures of speech that help to explain or illustrate an idea by comparing it to a familiar concept. In design, metaphors are often used to create appealing and meaningful user experiences by drawing on familiar concepts from the physical world or cultural associations. In order to create an effective and aesthetically pleasing product metaphor, the designer should carefully select a source that holds the intended meaning among their most essential properties, that has a relation to the target object and aligns with the designer's intentions for using the metaphor. The source should then be mapped to the target object to balance clarity and interestingness.





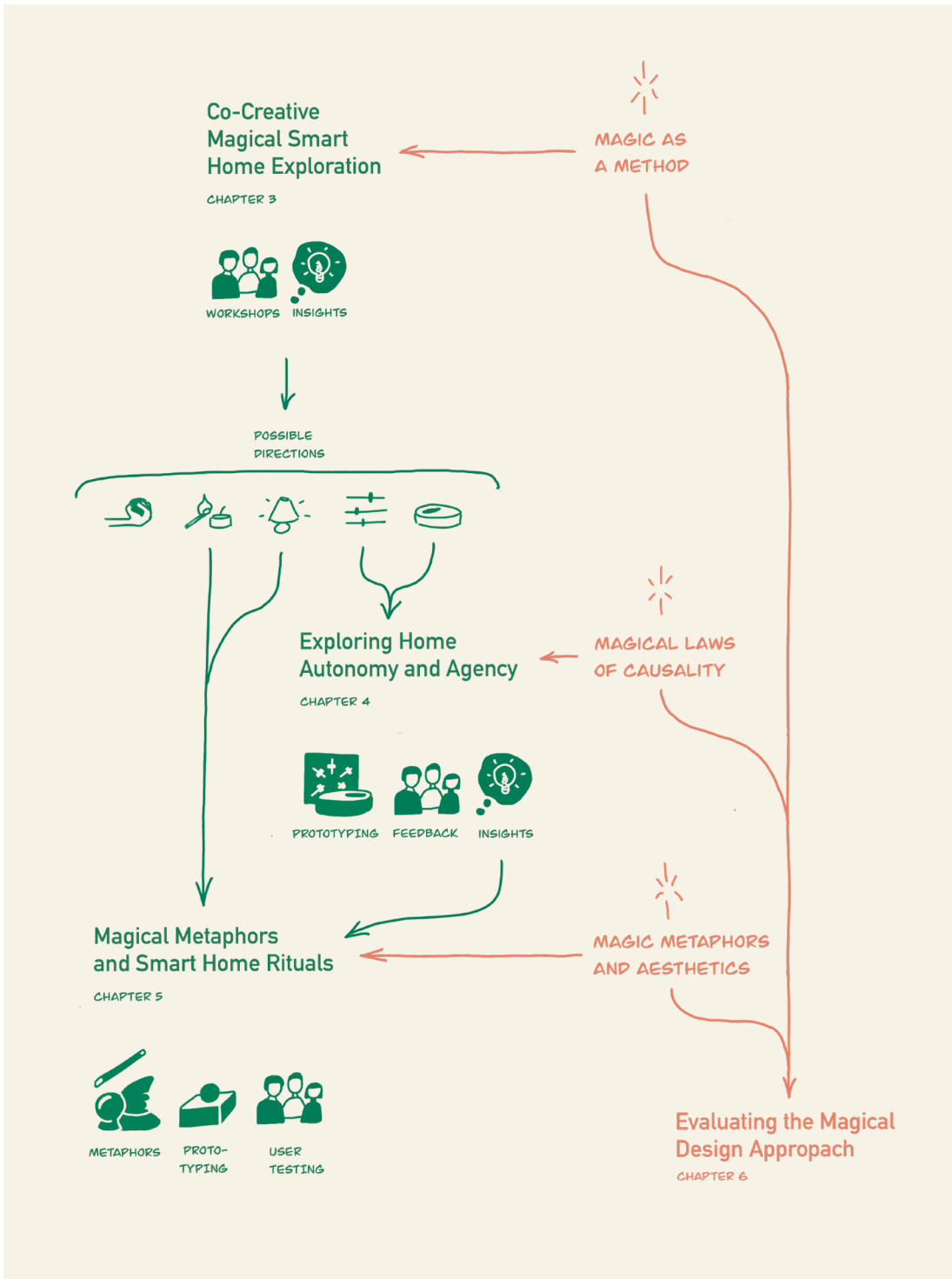


Image 2.1: An overview of our process.

# Process and Methodology

Image 2.1 shows our process. It consists of three main parts; co-creative magical smart home exploration, exploring home autonomy and agency, and magical metaphors and smart home rituals.

During the initial exploration, we leveraged magic as a method to conduct co-creative workshops on magical interactions in the smart home. From this, we identified five possible future directions; parameterizing the home atmosphere, negotiating agency between users and an intelligent agent, emotionally motivated actions that reflect the atmosphere or desired effect, light variation in the smart home, and interactions for actively opting in for being monitored.

In the second phase, we explored two of the possible directions; negotiating agency between users and an intelligent agent in the home, and parametrizing the home atmosphere. We leveraged animation magic to create two concepts with different degrees of agency which we used in feedback sessions.

Lastly, we brought with us what we learned about automation and control in the second part, and explored two other directions from the initial workshops: emotionally motivated actions that reflect the atmosphere or desired effect, and light variation. We leveraged magical metaphors to create an object that reminds users to create ambient lighting and were inspired by aesthetic properties from magic to create an interaction that holds emotional values. From all the parts of the process, we learned valuable lessons on the effects of applying magic to the design process in different ways.

## 2.1 Methodology

The methodological approach to this project has been largely qualitative, explorative, and emergent. Firstly, the approach has been qualitative in the sense that we have gained a contextual understanding of users through interviews, observations, and user tests with smaller user samples. The interviews have been semi- to unstructured, allowing for emergent topics and organic conversation in addition to the open-ended questions. This allowed us to focus on rich information, and understand the complexity of why users feel and think the way they do. (The Interaction Design Foundation, n.d.). Secondly, rather than staking out one path, we wanted to explore different directions which emerged from designing from a magical perspective. We started broadly and explored the emergent directions, in line with the concept of both explorative and emergent design. Emergent design is an approach where designers adapt to new ideas, concepts, or findings that arise during the study. Unlike more structured approaches, emergent design welcomes unexpected information, often leading to rich findings (Pailthorpe, 2017).

As mentioned our process did not start with a problem, but rather with a motivation for exploring alternative approaches in the smart home domain. Thus, the problem and the solution have both evolved through a co-evolutionary process as described by Dorst & Cross (2001). Constant learning has given us insight into what needs we should meet, and thereby what our solution should provide. Simultaneously, designing prototypes to use as boundary objects during user involvement provided further understanding of how the solution might solve the emerging problem. This way of developing artifacts as part of the research relates to "research through design", which typically consists of developing prototypes or artifacts that users might mistake for a product and plays an important role in the process of

generating knowledge (Stappers & Giaccardi, 2017). In our case, bringing magic into the process of designing prototypes and allowing users to interact with them in a home context generated knowledge about how magic might be a starting point for the creation of novel interactions in the smart home.

Inspired by experimental and discursive design, our project does not necessarily aim to create a product that serves the market. In experimental design, the primary intent is to explore different possibilities and investigate the design implications of a technique, material, concept, etc. (Tharp & Tharp, 2013). Or in our case: applying magic to design. In discursive design, on the other hand, design artifacts are tools for thinking and discussion. They could have functional value, but their reason for being is their discursive voice. (Tharp & Tharp, 2013). Although not entirely discursive, our design process during Chapter 4 (exploring home autonomy and agency) has been influenced by discursive design in the sense that we did not mainly focus on the desirability or usability of our designs during testing, but rather on raising discussions on how people want to interact with the smart home.

### **Privacy and Data Collection**

As our user involvement sessions involved audio and video recording, we applied to Sikt (Norwegian Agency for Shared Services in Education and Research) to collect the data, and were granted permission for all three rounds of user involvement. We received written consent from all participants, and the data has been handled according to Sikt's regulations. All the raw data will be deleted when the project has ended.

## Affinity mapping

To structure these rich and qualitative findings, all statements have been categorized and affinity mapped in Miro, to help identify commonalities and correlations (Image 2.2). Affinity diagramming help in synthesizing large volumes of mixed information and data, by first grouping similar pieces of data, and then discussing and clarifying these clusters (Dam & Siang, 2022b). In our case, we also created subgroups within the clusters to visualize and label the opinions that stood out within a topic. The emergent nature of our findings led to complex results that were often inconclusive. Mapping them out in a visual manner helped us see the larger lines, and make some general assumptions, despite this complexity.



Image 2.2: Extract from one of the affinity maps in Miro. This workshop was held in Norwegian.

## Wizard of Oz

During the initial workshops and the user testing of the final prototype, we utilized the Wizard of Oz technique. Wizard of Oz prototypes are intended to make users believe that the prototype is fully functional, like in the story of the Wizard of Oz where a deceptive appearance is generated from behind a curtain. A designer will mimic some key functions of the product, while aspects such as visuals are fully designed (Dam & Siang, 2022a).



# Co-Creative Magical Smart Home Exploration

This chapter describes the first phase of our process, where we explore what design directions appear when using magic as a starting point. Through user involvement, we look into people's associations with magic, their preferences regarding the home context, and how this can be related to the smart home.

We conducted workshops which investigated people's relation to interacting with different objects in a smart home context. The workshops were loosely based on the "magic thing" method: by asking people to think magically we hoped to remove the restrictions of reality and contemporary technology on their creativity, to inspire innovative and future-oriented ideas.

With our goal of moving away from conventional control interfaces, we encouraged users to interact with physical objects. We hoped that interacting with these objects in a magical way

would inspire possible sources for metaphors which could be leveraged for later concept and product development.

In addition to finding potential metaphors, we aimed to see what people experience as natural and logical interactions. We hoped that asking participants to think magically would encourage them to devise pleasurable interactions inspired by the aesthetic qualities from magic.

We also aimed for the workshop to raise discussions about other qualities of the home context, such as personal routines, people's interest in creating an atmosphere, and small rituals that they enjoy performing.





## 3.2 Procedure

First, we conducted a warm-up exercise to get people into the mindset of magical thinking. The exercise was quite simple, firstly, without mentioning magic, we asked people to demonstrate alternative ways that a remote control could be used (such as a serving tray, a door stopper, etc.). After becoming comfortable with generating unconventional ideas, we presented the participants with a clay torus and asked them to imagine what it could do if it were magical. During both of these warm-up exercises, we encouraged the participants to physically act out the use cases they imagined, to get them in the mode of thinking physically and showing rather than telling. This is a method of embodied sketching, specifically "use-case theatre", proposed by Segura et al. (2016) to start designing for bodily experiences early in the design process. They suggest this activity-centered approach as a way of ideating for embodied interaction.

Next, during the main task, we asked participants to explore ways of interacting with light and sound using the objects in this room. The users were asked to think aloud so that we could Wizard of Oz their intended actions. To encourage a range of different interactions, we asked them to first interact with one object, then to organize and compose objects, and lastly how the smart home could communicate through objects. Lastly, we asked the participants to take turns in acting out a scenario, and asked follow-up questions about the workshop experience, and questions related to smart homes, personal routines and magic.



This is an abbreviated version of the procedure. The full procedure of the workshops can be found in Appendix B.

## 3.3 Results

### 3.3.1 Participants

We conducted a total of four workshops, two with three participants each, and two with two participants each. All participants but one of them were design students. Most of the participants lived in a shared flat with one or two friends, the two exceptions were two participants living with their partner, one of them with their kids. Their living situation is relevant because it might affect how strongly they relate to their home and their care for adjusting the home atmosphere to their preferences.

#### Workshop 1

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<b>P1</b> woman mid-20s lives with two acquaintances	<b>P2</b> woman mid-20s lives with one friend	<b>P3</b> man mid-20s lives with one friend
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#### Workshop 2

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<b>P4</b> woman mid-20s lives with partner	<b>P5</b> woman mid-20s lives with partner and kids	<b>P6</b> woman mid-20s lives with two friends
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#### Workshop 3

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<b>P7</b> man (not designer) mid-20s lives with one friend	<b>P8</b> woman mid-20s lives partner and one friend
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#### Workshop 4

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<b>P9</b> woman mid-20s lives with two friends	<b>P10</b> woman mid-20s lives with one friend
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### 3.3.2 Main Findings

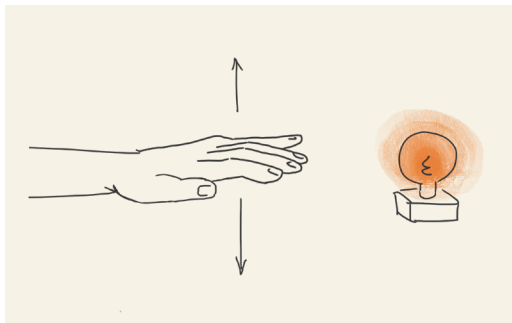
 This is an abbreviated version of the results. A more elaborate version can be found in Appendix C.


#### Magical ideation

When asked to think of magical ways of using the ceramic torus in the warm-up session, the participants came up with far-fetched and futuristic ideas related to time, place, and super-human abilities. When starting the main task, some participants stated that they found it hard to free themselves from their knowledge of technology.

*"It was easier to think magically with the ring during the warm-up. You think too technologically when controlling light and sound." –P3*

#### Interactions



 The participants performed a wide variety of interactions. See Appendix D for an illustrated overview.

#### Gestures

All participants instinctively went for gestures when interacting with the smart home, and related this to magic.

*"If an interaction were magical, it would be because I felt like I had magical powers in interaction with something. Snapping or clapping, for example. 'Wow, I can do this!' Then I would feel magical."*  
–P10

#### Physical interfaces

The advantages of digital and physical interaction modalities were discussed in all the workshops, where the main divide was between convenience and pleasure. Digital interfaces offer availability, however, two participants were hesitant to spend even more time on their phone, where one of them was discontent with the feeling of interacting with a voice assistant.

*"I don't want to pick up my phone unnecessarily, suddenly you end up in a loop." –P5*

*"It's not very sexy to be shouting at Google". –P7*

The perceived advantages of physical interfaces were motivated by aesthetics, feeling more present in the world, and the tangible dimension making it less scary and futuristic.

*"It becomes less technological and more magical. It brings it back to the real world. It is not necessarily connected. But it makes it less 'futuristically scary', which is what you want to work towards." –P10*

#### Automation

Multiple participants associated magic with a smart home that could understand and adapt to the kind of home atmosphere they wanted. Three participants said that they enjoy a cozy mood created by lights and music, but that they might forget to set it themselves, and would appreciate the smart home to be an initiator.

*"I like cozy lighting, but I either forget to turn on the light that creates a cozy mood or I'm too lazy to go and do it. I would appreciate if the smart home knew that 'at 4 pm, she likes this and that to happen'." –P10*

Another two participants added that they would like to be surprised by small variations in their pre-defined scenes, to add some degree of unpredictability and animacy to the smart home.

*"The lights notice when you enter the room and adjust to a predetermined scene. I could appreciate a little variation every time I enter, like with the weather, for example, the lights could compensate for rain by making it extra cozy. It lives its own life."*  
-P3

Two participants resented automation because they feared it would deprive them of actions that they enjoy doing, and three were reluctant to completely relinquish control to the smart home, due to a need to feel in control.

*"It's not the right thing for me. I get the sense that the goal is to make things more efficient and convenient. I'm old-fashioned when it comes to new things, what does it give me and what does it take? I appreciate things that slow down the pace, small pleasures I can do in my everyday life."* -P9

*"You have to be able to maintain control over the actions yourself, with automation it becomes a robot movie-like feeling, but if you initiate the automatic action it can be nice."* -P6

### **Separating practical tasks from emotionally motivated actions**

In all four workshops, the participants discussed the trade-off between convenience and emotionally motivated actions for setting the home atmosphere. In most situations, they preferred a simple and familiar way of controlling the light and sound. However, two participants suggested an added emotional value of introducing a more tangible and aesthetic interaction.

*"It is important to separate hygiene factors from having a ritual. For hygiene factors, I want to reach out and do designated gestures to turn it on and off. In a ritual, I want to make a bigger deal of it, like lighting a candle or putting on a record."* -P3

*"For everyday life, it is better that things are kept simple. But if I have guests over it could be interesting to have a ritual where I can magically evoke the right ambiance."* -P5

### **Understanding automated actions**

One participant felt uncomfortable with not being able to understand the "thoughts" behind the automated actions of the smart home.

*"How can we understand an intelligent object? The smarter it is, the less we understand how it works. There is a creepy sensation, how does it know how I am feeling?"* -P1

Although the suggestions made by some participants would require some degree of monitoring, two participants responded that they do not like the feeling of being observed, especially if under constant monitoring.

*"I feel uncomfortable being monitored. It should preferably be something that is not done all the time, to ensure a feeling of autonomy."* -P7

### **Magic means breaking with the expected**

Three participants associated magic with something unusual, an exception from what is expected. One also mentioned that the initial awe of magic disappears once you get used to it and becomes a part of everyday life.

*"The automatic lights in our garage were magical the first time we saw them. But now we know how it works. And if you do something every day it's not magical anymore."* -P9

### Human-smart home dialogue and negotiation

In the workshops following the pilot, participants were encouraged to think of ways of physically conveying the status of the smart home; how the smart home interprets a situation, or what changes it is planning to make. One participant suggested a pillar of stacked disks, where the disks would slowly protrude from the pillar if the smart home were planning to change something (Image 3.3).

The user could then abort or revert these changes by pushing them back in. One of them suggested a composition with a stick placed on top of a cylinder (Image 3.4). The stick would rotate based on which mode the smart home wants to trigger.

Several participants emphasized the importance of being able to stop unwanted changes initiated by the smart home.

*"Interrupting unwanted changes should feel like removing the needle from a record player" –P10*

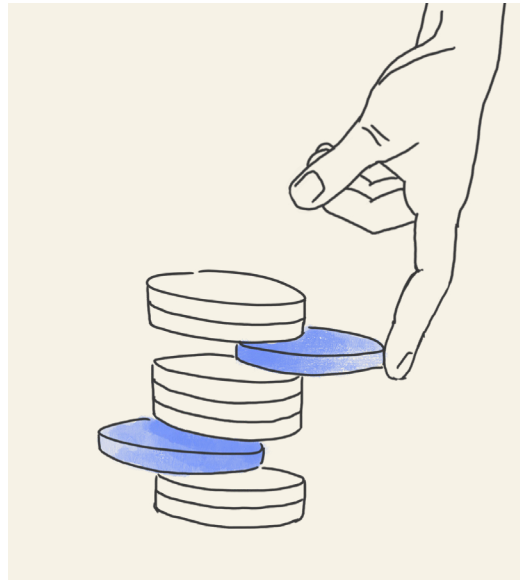


Image 3.3: One participant suggested a stack of disks to convey the status of the smart home.

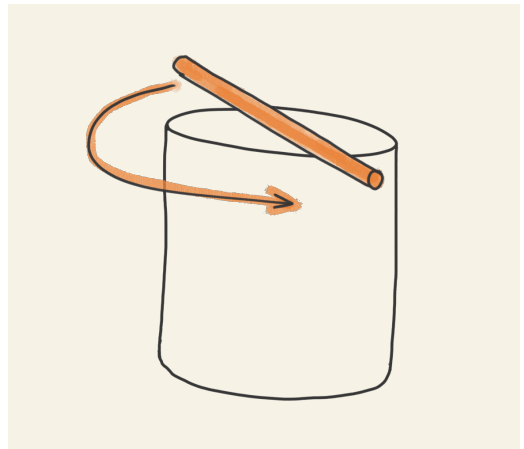


Image 3.4: Another participant suggested a rotating stick which indicates which mode the smart home plans to activate.

## 3.4 Limitations and Considerations

### **A wide spread of emergent topics**

The “magic thing” method utilized in the workshop opens for creativity in the participant’s current task and allowed for diverse and emergent themes to be explored. However, it also resulted in a wide spread of topics covered and different discussions in each workshop. As a result, the method may have led to quite sweeping and less thorough findings. Additionally, some things that came up naturally in one workshop may have been encouraged or brought up by us in another, which may have pushed the participants to discuss topics that they would not naturally bring up.

### **Objects influencing interactions**

The use of specific objects in the workshop led the participants to focus on tangible interactions instead of interacting in the way that would be most natural to them. Additionally, the size and properties of the objects (such as some resembling other, familiar objects) may have primed participants to think in a particular way, which may not have been representative of their actual preferences. However, the scale of the objects was in line with objects that we would typically find in a home.

### **Participant homogeneity**

The homogeneous nature of the participants, consisting mainly of designers in a similar age group, may have limited the diversity of perspectives and experiences represented in the workshop. The number of participants and their living situation may also have had an effect on the relevance and validity of the findings.

Despite the limitations of our findings, they were primarily intended to inspire further concept development and serve as a source of inspiration for new interactions in the smart home, which was accomplished.

# 3.4 Discussion

## 3.5.1 Gestures

The frequent and immediate occurrence of gestures for direct control makes sense both from a biological and a socio-cultural perspective. Firstly, using our bodies to show our intention is a fundamental part of human communication. The directed movements toward different lamps observed in the workshops are known as deictic gestures – communicative acts where someone directs attention toward something in their surroundings (Ware, 2008). Deictic gestures are integral to the way humans communicate from an infant stage (Rohlfing et al., 2017) and include pointing, looking at, or orienting your body in the direction of the object of interest. The same can be said about the observed gestures that connect lamp brightness and vertical movement.

Finally, the frequent occurrence of hand gestures makes sense from a magical perspective for two main reasons: they are intuitive and natural, and are common cultural references from magical stories. Gestures can feel like an extension and embodiment of a person’s intentions, by allowing them to directly manipulate their surroundings. This gives people a magical feeling of affecting physical objects through the effort of will, or ‘mind-over-matter magic’ as defined by Subbotsky. Secondly, hand gestures are associated with magical or supernatural abilities in many cultural and mythological stories, such as using “the Force” in Star Wars, or performing spells using wands in Harry Potter.

All in all gesture-based interaction appear to be inherently intuitive. However, this is challenged from a privacy perspective, as it requires users to be under constant monitoring, in order for gestures to be noticed. Our findings confirm that many users might find this problematic:

*“I feel uncomfortable being monitored. It should preferably be something that is not done all the time, to ensure a feeling of autonomy.” –P7*

Gesture-based control is also problematic from a discoverability standpoint. Similarly to voice commands it relies on linear, out-of-context knowledge in the head and provides no feed-forward knowledge in the world. Don Norman (2010) stated that “gestures lack critical clues deemed essential for successful human-computer interaction”. He argues that pure gestural systems provide little information about interaction possibilities and the specifics of the execution.

If the gesture-based system is intended to work without a hand-held device, The Midas touch problem becomes relevant: unintentional gestures might be recognized as deliberate commands (Freitas et al., 2023).

To conclude, the fact that people instinctively went for gestures makes sense both from a biological point of view and in relation to magic. But it is also practically challenging from a discoverability standpoint and with the risk of the Midas touch problem.

### 3.5.2 Degree of Automation and User Control

Automation was an emerging topic in the workshops because participants associated it with the idea of having a house that “just knows” how they would like their lights, akin to magic. This sparked a discussion on how much agency the participants would want to grant their smart homes.

#### **When automation is desirable**

Some degree of automation was appreciated by the participants, such as the ability to automatically trigger predefined scenes based on their routines or activities, as well as automating mundane tasks such as temperature control and watering plants. Brush et. al. (2011) found that people welcome automation when it offers convenience and the research of Garg & Cui (2022) shows that people assign complete autonomy to their devices when it comes to routine and mundane tasks. We find the same thing in magical stories from popular culture, myths, and lore, where magic is often depicted as being able to automate mundane tasks such as cleaning, packing, carrying, etc. For example, in the Harry Potter series, the Weasley family uses magic to clean their dishes, and Hermione Granger is known for using magic to pack her trunks.

The research of Brush et. al. (2011) discusses whether people want devices in a living room to ask permission before making decisions, or if they should act autonomously. They also found that users wish for devices to act autonomously on actions with a low cost/impact (including the user’s cost of reverting the action), and a low perceived possibility of being wrong. This would be the case for the situations mentioned by the participants considering the predictability of routines, and the low risk connected to mundane tasks and minor adjustments.

However, many participants were positive towards automation because the smart home could help them remember to set a cozy atmosphere with light and sound settings, as they might forget to do it themselves. This suggests that automation is not merely a tool providing convenience, but that it can serve to create an entity that acts as a personality in the home, like a friendly butler or a family member offering something that you didn’t know that you wanted.

#### **When the user wants to be in control**

Coyle et al. (2012) found that users experienced a detectable loss in their sense of agency when the provided assistance from a device exceeds a certain level. This might explain why our participants – regardless of their opinion on automation and device agency – agreed on the importance of being in control of their own homes. They expressed frustration with the thought of the smart home making autonomous decisions without them being able to deny or adjust the automatic action. Some of our participants suggested ways of overriding the automated actions to regain some degree of control.

However, not wanting automation was motivated by more than the need for control. Some participants expressed skepticism towards a large degree of automation in the smart home because they enjoy performing certain actions, such as setting the atmosphere of a room, lighting a candle, and preparing their own food. This suggests that “what should not be automated?” is an equally important question, and that incorporating pleasurable interactions with smart homes could be a promising direction for further work. We will discuss this further later in this chapter, with regard to interactions that hold emotional values rather than convenience.



### Expressing device agency

Some participants felt uncomfortable with the inexpressive nature of smart home devices, and the lack of transparency in the reasoning behind the automatic actions. As one participant stated: “How can we understand an intelligent object? The smarter it is, the less we understand how it works. There is a creepy sensation, how does it know how I am feeling?”. Jia et al. (2012) found that when IoT-enabled objects showed some degree of agency, users were concerned about controlling or dominant objects and that this distrust lies in the automaticity of the technology and the invisibility of its manufacturer.

### Negotiating agency between users and devices

Cila et al. (2017) suggests designing with both human and non-human agency in mind, and the interdependence between them. This is supported by the findings of multiple scholars, as formulated by Garg & Cui (2022), who emphasize the importance of understanding how agency can be negotiated between users and objects such as IoT devices. The compositions suggested by our participants can be an example of how user and object agency can be negotiated in a tangible way.

## 3.5.3 Physical and Digital Interfaces

Although many participants emphasized the value of being able to control your home from anywhere using voice control, its usability issues mirror those of gestures: these commands require linear knowledge in the head. In the case of voice commands it means that users need to know exactly what to say to activate a certain function or device, which can be challenging because there are no visible clues to guide the user.

Controlling the smart home from anywhere can easily be achieved using a smartphone. However, our workshop findings suggest that people see emotional values, rather than convenience-related values in physical interfaces, such as being more present in the world, closer to the thing you want to control, making smart homes appear less “futuristically scary”. This aligns with the hedonic perspective on embodiment of Van Campenhout, et al. (2019).

Physical interfaces help us reduce the use of the “glass slabs” that dominate our current relationship with interactive technology. As backed up by one participant:

*“I don't want to pick up my phone unnecessarily, suddenly you end up in a loop.” –P5*

Natural materials oppose the typical “technological” look of smart home devices, and one participant linked these materials to magic. In magical stories and lore, materials such as wood, stone, and clay are often used in the creation of magical artifacts, thus, encouraging participants to think magically might have affected which materials they were drawn to in the workshop.

However, it is worth discussing the practicalities of incorporating tangible user interfaces and physical objects into smart homes. One of the main considerations is its flexibility. Bell et al. (2003) noted that homes differ in appearance, social units, and ways of living, which might pose a challenge to designing TUIs for home IoT systems, as physical objects might not be easily adaptable to different homes. This practical problem is also addressed by Joep Frens (2017), who explores different approaches to how embodied and rich interaction can be combined with the dynamic, “growing” nature of home IoT systems. During the workshops users also mentioned practical problems such as the risk of losing small items.

### 3.5.4 Balancing Emotional Engagement and Convenience

Our findings revealed that people appreciate simple and familiar ways of controlling their homes for everyday tasks, but they see an added emotional value in more tangible and aesthetic methods for setting the mood when entertaining guests or indulging in self-care. As stated by one participant:

*"It is important to separate hygiene factors from having a ritual. For hygiene factors, I want to reach out and do designated gestures to turn it on and off. In a ritual, I want to make a bigger deal of it, like lighting a candle or putting on a record."—P3*

As mentioned with regard to automation and user control, our participants did not want certain actions to be automated because they enjoy performing them. Some preferred immersing themselves in the task of creating a cozy environment, and it was suggested that initiating ambient lighting through an emotionally motivated action enhanced the feeling of preparing for quality time. This is in line with the argument of Lenz et. al (2013) of designing for interactions that build a bridge between the "how" level (in this case, the interaction) and the "why" level (wanting the cozy mood).

### 3.5.5 Magic as a Creative Method

Leveraging magic for free thinking was more successful in the warm-up exercises than in the main task of the workshop. We learned that the use of magic sparks more creative ideas when people are not restricted to controlling light and sound. It appears that asking participants to control light and sound directed them back to operating familiar technology, and thus, to familiar ways of operating it. As stated by one participant:

*"It was easier to think magically with the ring during the warm-up. You think too technologically when controlling light and sound."—P3*

This indicates that using magic as a creative tool might be more suited for open exploration than in tasks where the interaction and surroundings are closely linked to how things are currently operated.

However, although the concrete ideas and magic concepts that emerged were less innovative, we still got a sense of the aesthetic qualities that people appreciated. The participants' perception of magic as something that defies expectations may be the reason why they expressed interest in unpredictability and variation as a property in the smart home. The interest in emotionally motivated actions or rituals might have been inspired by the use of rites and charms in magical stories.

### 3.5.6 Possible Future Directions

Based on our findings and discussions, we identified five possible directions:

#### **Emotionally motivated actions that reflect the atmosphere or desired effect.**

We were intrigued by the idea of creating an aesthetic interaction, where the action itself reflects the atmosphere that you aim to induce by performing it.

Our findings show that people enjoy performing certain rituals for setting the mood such as lighting a candle or putting on a record. They see the value of having more tangible and aesthetic methods for setting the mood when entertaining guests or indulging in self-care, and it could be interesting to explore how new smart home interactions could incorporate such rituals.

#### **Interactions for actively opting in for being monitored**

Another possible direction was to explore the idea of actively choosing to be monitored by the smart home, such as by picking up an orb that monitors your heart rate or temperature, or by asking an intelligent agent to learn from your actions during a specific period of time. This would be a way to get around the creepy sensation of constant monitoring, by giving users complete control of when and how they want the monitoring to happen.

#### **Light variation in the smart home**

We were also intrigued by exploring the use of organic movement and variation in light in the smart home, to enhance the sensation of the house being a living entity, and thus drawing upon animacy in magic. Fluctuating light could be used to enhance different moods and add a "magic" touch to interactions and rituals. It could also bring the organic changes of the outside world throughout the day, into the home atmosphere.

#### **Parameterizing the home atmosphere**

Another question that emerged from the workshops was how the experienced mood or atmosphere in the home could be parameterized. Would it be desirable to set the mood of your house by controlling parameters such as brightness, intensity, warmth, and "coziness", instead of controlling individual lights?

#### **Negotiating agency between users and an intelligent agent**

Lastly, we saw the potential of exploring how a physical object could facilitate the negotiation of agency between users and an intelligent agent in the smart home. Our findings showed that people appreciated some degree of automation, while still wanting to stay in control. By letting an intelligent agent learn from you, it is less likely to make mistakes. And by being able to correct it, users will feel like they are in control (and the correction will also be part of teaching the AI). With this direction, we also wanted to explore whether the agent should act autonomously, or be limited to making suggestions.

Due to the participants significant focus on autonomy in the workshop, we decided on pursuing this direction as our next design exploration. Autonomy and agency are large and complex topics, naturally touching upon parametrization and monitoring. This will be the topic of the next chapter. Ideas such as light variation and aesthetic interactions for setting the atmosphere will be revisited later in the project.



# Exploring Home Autonomy and Agency

During the workshops, multiple participants associated the notion of magic with a smart home that could understand and adapt to the kind of home atmosphere they wanted for different activities and times of the day. For example, one participant said, "When I enter the room, the home should know which lamps I like to have on." Another participant said, "When I turn on the TV, the lights should dim." Yet another participant said, "At 4 o'clock, the home should know that I like a cozy atmosphere." As technology advances and AI becomes more sophisticated, it is likely that advanced sensing combined with machine learning will lead to smart homes that comprehend and act as if they were all-knowing, almost like magic. We want to preempt the likely future of AI entering our homes, and raise the question, how would people experience having such an omniscient entity in their homes?

However, many also expressed reluctance to completely relinquish control to the smart home. Some were frustrated at the thought of not having an easy way to oppose the smart home's choices or to take control away from it completely. These experiences, as well as ideas that emerged in the workshops, led us to pursue the idea of a physical negotiation between the smart home and the people who live there. We envision an intelligent agent in the home, with an almost magical ability to understand the habits and preferences of the inhabitants. It makes its own decisions and

predictions regarding the home atmosphere, and conveys them through a physical interface, hopefully make its AI's reasoning seem less creepy. The interface can also be manipulated by users, which we hope will give users a sense of regaining control.

The physical interface will move and change according to decisions made by the intelligent agent. The idea of an object living a life of their own aligns with the magical concept of animacy. As mentioned, animacy can involve imbuing inanimate objects with a sense of life or consciousness. This can involve giving objects personalities, desires, and the ability to move and act on their own. We used animacy as a design mechanic to create a smart home interface that feels less digital and more like a living entity that can be negotiated with.

We made two concepts, which represent two different modes of interaction as well as two different levels of device agency: An important research question is which level of agency people would want for such an agent.

## 4.1 Concept 1: The Weather Vane

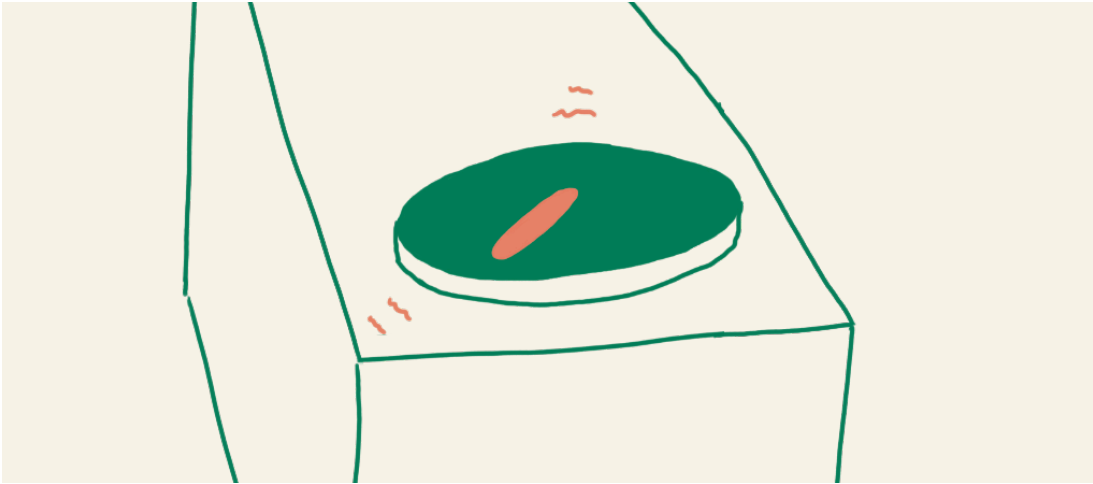


Image 4.1: The weather vane

The first concept was inspired by a metaphor used by a participant in the initial workshops: That preventing actions performed by an autonomous agent should feel like removing the needle from a record player. The concept consists of a mood indicator that rotates slowly when the home system plans to change the atmosphere (Image 4.1). When the user hears the indicator grinding against its underlying platform, they will have time to interrupt the intended change. In addition to learning from your domestic habits, all user input, such as interruptions and personal choices, will be serve as input to the underlying machine learning model, effectively combining unsupervised and supervised learning. If the user grows tired of the automatic changes, they can “remove the needle from the record player” by removing the indicator from its platform.

The pointer sits on top of a base and rotates around its axis. Markers for different atmospheres are distributed around the base’s surface and are activated when pointed at. When the intelligent system predicts that an atmosphere change is appropriate, the pointer will rotate slowly to the marker indicating that atmosphere (Image 4.2). The pointer can also be rotated by the user, either to interrupt a change suggested by the magical entity or to activate a scene of their choosing (Image 4.3).

We envision the overall aesthetics of the product to include natural materials such as a clay pointer slowly turning on a stone base. Inspired by ambient intelligence, we did not want the object to demand users attention, but rather using more subtle means for displaying changes. Motivated to make a product with a less digital feel we wanted to use the analogue sound of materials grinding against each other as a faint notice to the user.

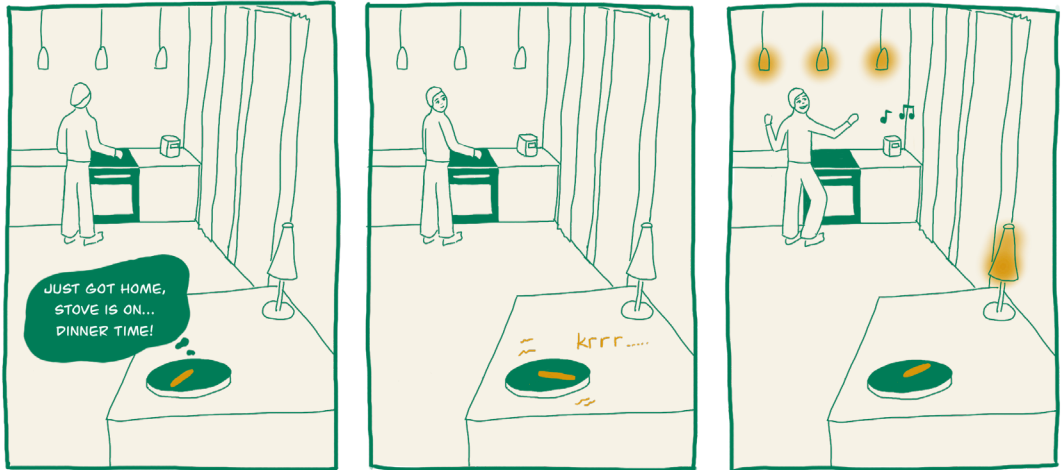


Image 4.2: Scenario 1 – The Weather Vane makes a change appreciated by the user.

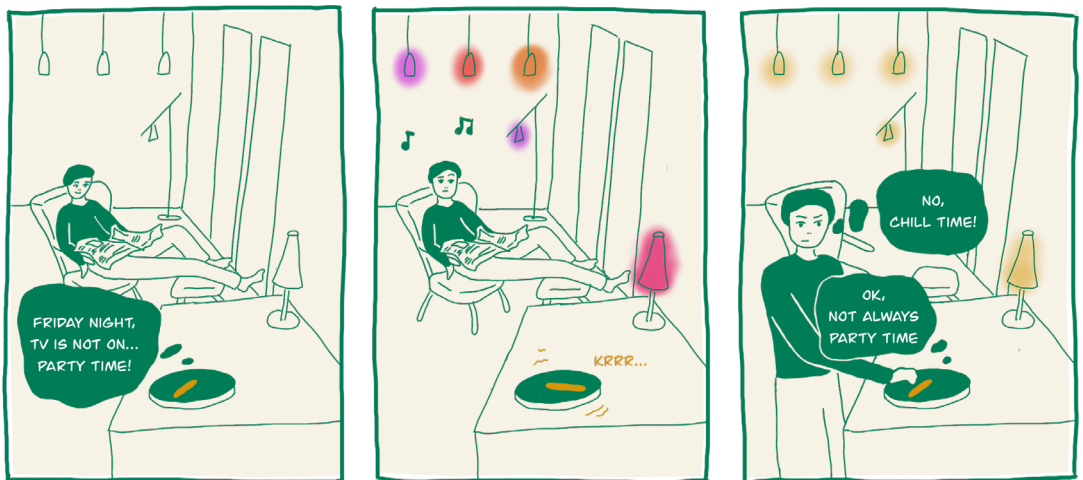


Image 4.3: Scenario 2 – The Weather Vane misinterprets the situation and the user reverts the change, which becomes part of its training data.

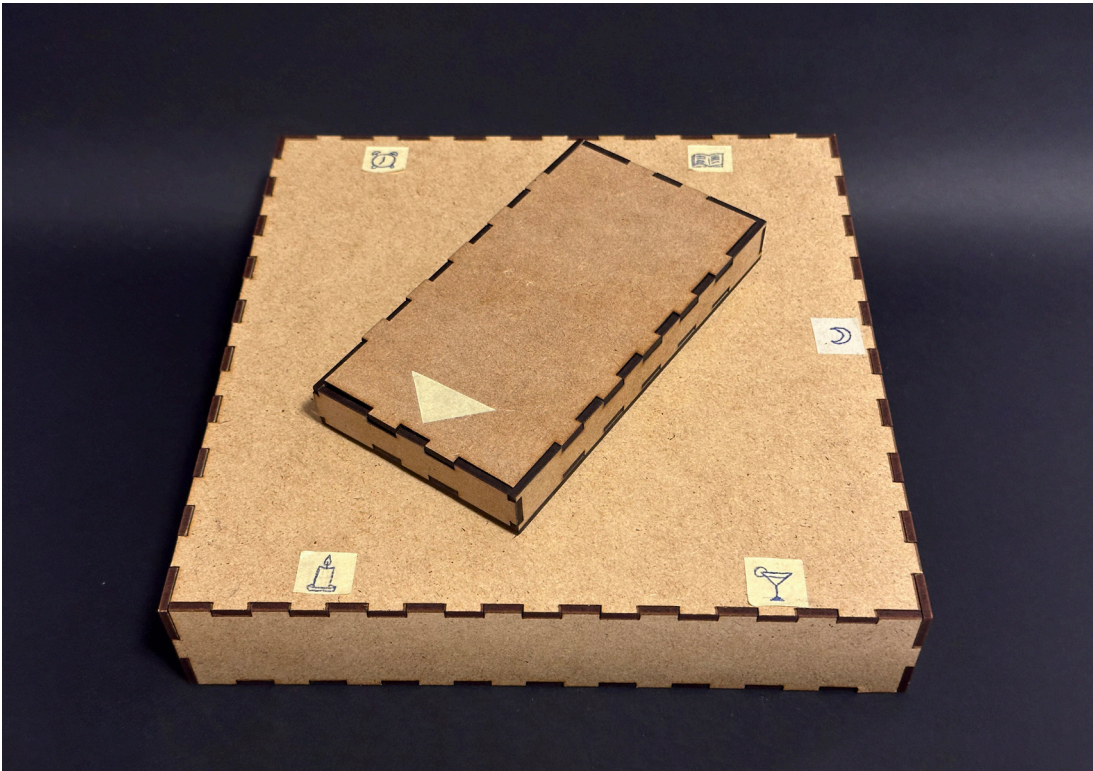


Image 4.4: The functional Weather Vane prototype

### 4.1.1 Concept 1 Prototype

We made a functional prototype to simulate automatic changes in a testing context (Image 4.4). The prototype comprises a base square that houses a continuous servo motor, which is connected to a small disc. A pointer sits on this disc, which fits into a circular cutout on the pointer's bottom surface. The friction between the pointer and the disc connected to the servo is sufficient to rotate the pointer, while it remains independent of the servo to allow the user to rotate it.

Figure 4.1 shows an overview of how the prototype works. The pointer houses a phone that sends compass data over OSC (Open Sound Protocol) to a PC. The logic on the PC is handled in TouchDesigner. The compass course is then

used to control the motor, which moves until the pointer accurately points to the correct scene marker. When a user rotates the pointer to a scene, the compass course is used to activate the corresponding scene.

Signals are transmitted from the PC over Wi-Fi using the MQTT protocol to an Arduino Wi-Fi microcontroller that controls the servo, and to a smart home server that manages the room lighting. When a scene is activated through the interface, the lighting changes, and for the relevant scenes, music is played through a Bluetooth speaker.

To illustrate the concept, we predefined five modes; party, study, morning, and cozy, with corresponding light settings, and for some, related music. These were not named explicitly but were indicated with icons.



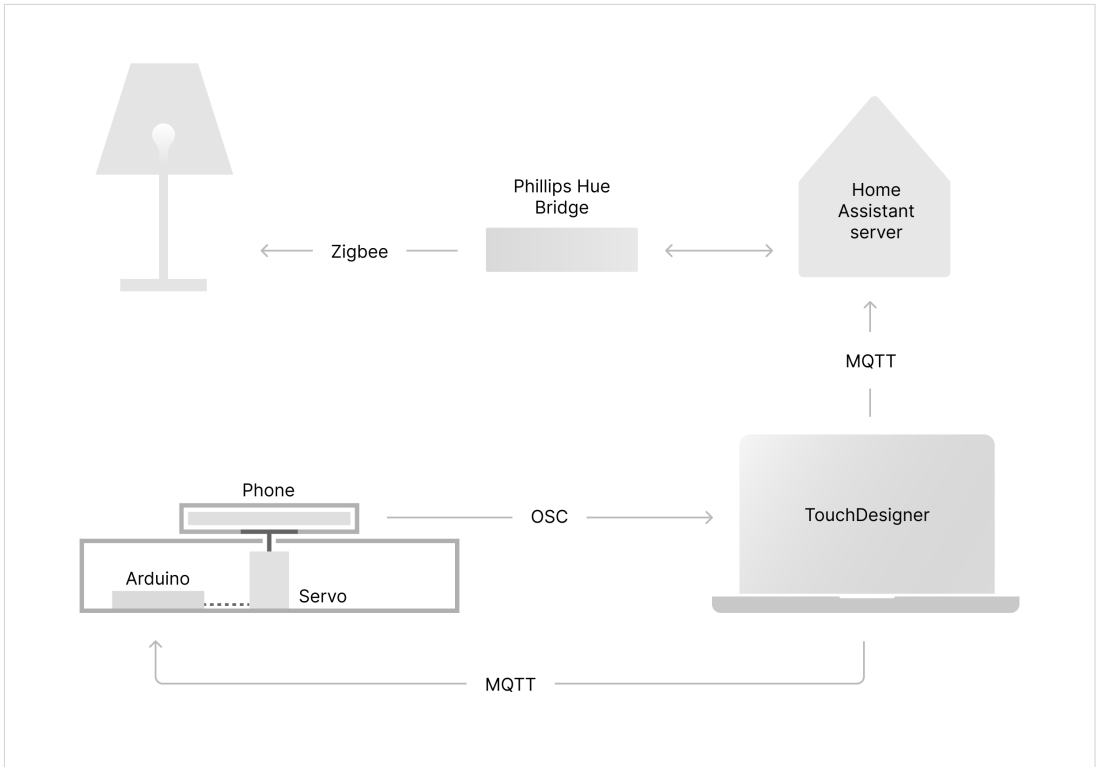


Figure 4.1: A schematic of the functional prototype.

## 4.2 Concept 2: Barriers and Equilibrium



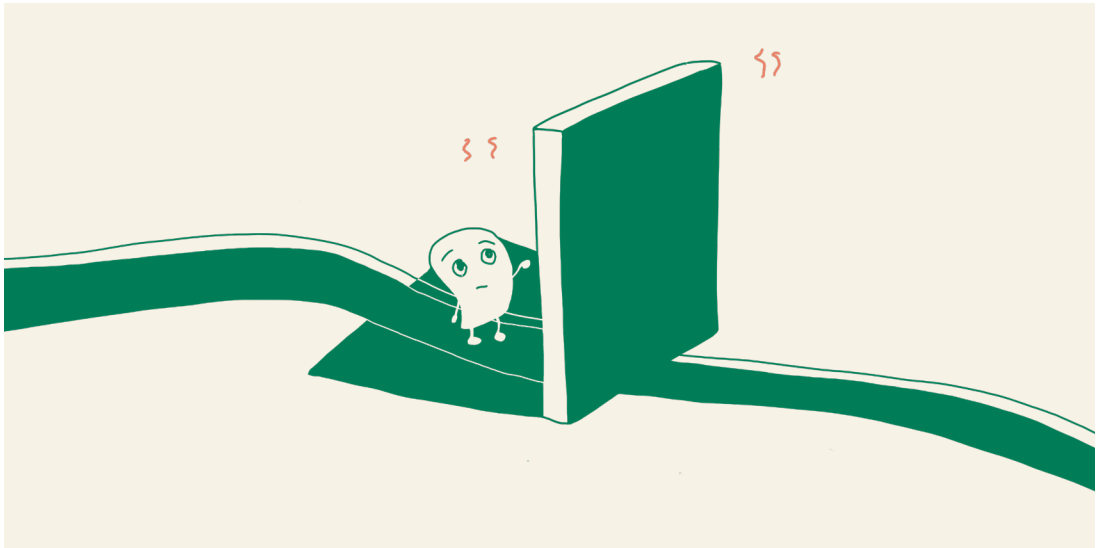


Image 4.5: The metaphor of magical agency is used to make limiting the agency of an autonomous agent more tangible.

The second concept arose from imagining how we can express the control and constraint of an intelligent agent through physical metaphors.

In this concept, setting a certain home atmosphere is described as offsetting the home from its base state. The base state represents the typical lighting and sound settings in a room. The interface enables more nuanced control of the home atmosphere by allowing users to adjust the atmosphere to a certain degree, rather than only selecting a pre-set scene as in the first concept. The equilibrium is represented in the interface as a centered circle, with small entities representing different parameters that can adjust the atmosphere. These parameters could be the intensity of a specific mood setting, or a more general characteristic such as light temperature or the tempo or volume of the music.

When all the entities are inside the circle, the home is in the base state. The value of each parameter is determined by how far away its

entity is from the center circle. If the "magically" intelligent home predicts that a change of atmosphere is appropriate, the relevant entities will try to move against the barrier, making small clicking noises as they attempt to pass it (Image 4.5). If a user agrees with the proposed change, they can move the barrier and allow the entity to slide to the proposed parameter value (Image 4.6), or simply ignore it or push it back to the center if they disagree. Alternatively, if a user wants the smart home to control a parameter freely, they can decide to leave the barrier out of the entity's path and allow it to move without asking for permission. The entities' positions can also be adjusted manually by the user. The fact that this TUI exist in a physical form allows to makes use of physical constraints to communicate whether the parameters are being blocked, and the physical affordance of the barriers may help guide the user in how to interact with the interface, as described by Shaer & Hornecker (2009).

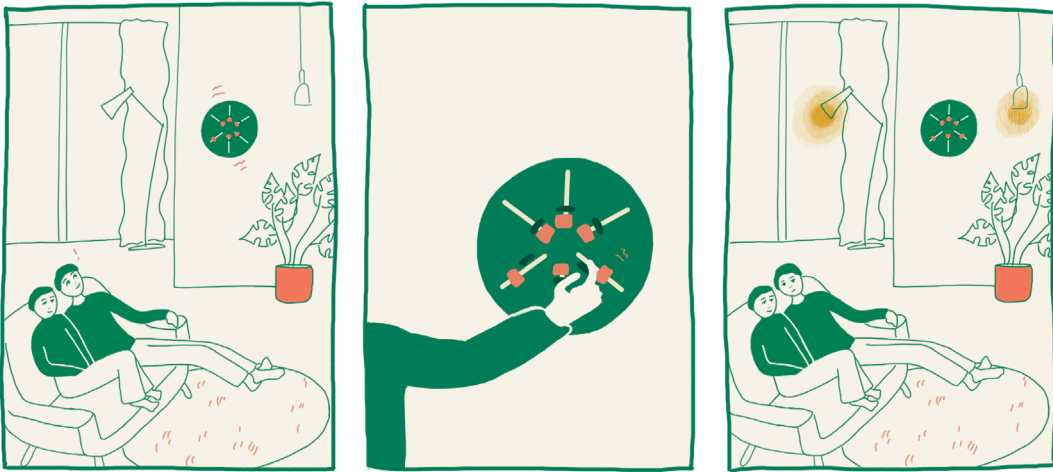


Image 4.6: Scenario of use for the Barriers and equilibrium concept.

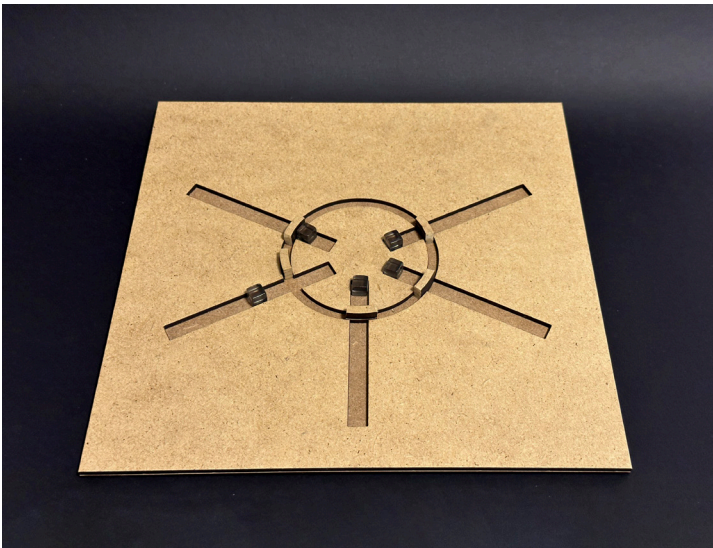


Image 4.7: The mockup of the Barriers and Equilibrium concept.

### 4.2.1 Concept 2 Mockup

The second concept was illustrated with a simple mockup (Image 4.7). It consists of a square slab with five tracks and a circle indented into the top surface. Small glass cubes are placed in each track, and small walls are placed in the circular indentation to block the cubes' trajectories.

## 4.3 Feedback Sessions

The main goal of the feedback sessions was to understand how our concepts are perceived and to investigate people's attitudes towards living with intelligent agents that aim to facilitate a better home atmosphere. We also aimed to learn more about the desired balance between user control and device agency and proactivity. In addition, we wanted users to engage in discussions on how the intelligent entity should learn, when it should follow you, and when it should act on its own.

### 4.3.1 Setup

The interviews were set up similarly to the initial workshops, using the same lamps and furniture to create a smart home environment in the UX lab.

As co-living was one of the things we wanted to discuss in the interviews, we now decided to narrow down our participant selection to people who are living together. As conflicting interests in multi-functional spaces like living rooms are part of the complexity that has to be taken into consideration in the field of home automation.

### 4.3.2 Procedure

We started out with a warm-up discussion about smart homes, emotional qualities, and personal preferences when it comes to setting the atmosphere at home. Next, we introduced participants to smart home intelligence, automation, and agency, followed by demonstrating and asking questions about the first prototype (The weather vane). Then we discussed the second concept (Barriers and Equilibrium) using the mockup. Lastly, to demonstrate the full range of agency, from complete autonomy to no agency, we describe a hypothetical entity that is only allowed to make changes when you pick it up.



This is an abbreviated version of the procedure. The full procedure of the feedback sessions can be found in Appendix E.

### 4.3.3 Results

#### Participants

We conducted five feedback sessions, in which all five pairs of participants lived together. Two of them lived in shared flats with multiple people, two of them were close friends living alone in a more established apartment, and one pair was a married couple living in a house with their two kids.

Coincidentally, all the pairs consisted of one person with a design education, and one person with an education in engineering.

#### Feedback session 1

---

**P1**  
woman (designer)  
mid-20s  
lives with P2 (partner) and  
young children

**P2**  
man  
mid-20s  
lives with P1 (partner) and  
young children

#### Feedback session 2

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**P3**  
man (designer)  
mid-20s  
lives with P4 (friend)

**P4**  
woman  
mid-20s  
lives with P3 (friend)

#### Feedback session 3

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**P5**  
man (designer)  
mid-20s  
lives with P6 + 2 other friends

**P6**  
man  
mid-20s  
lives with P5 + 2 other friends

#### Feedback session 4

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**P7**  
woman (designer)  
mid-20s  
lives with P8 (friend)

**P8**  
man  
mid-20s  
lives with P7 (friend)


#### Feedback session 5

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**P9**  
woman (designer)  
mid-20s  
lives with P10 + 2 other friends

**P10**  
woman  
mid-20s  
lives with P9 + 2 other friends

## Main findings

 This is an abbreviated version of the results. A more elaborate version can be found in Appendix F.

### There is skepticism towards automation when it is unclear why certain actions are triggered.

This skepticism was expressed through doubts about the system's proper functioning. These doubts stem from either a lack of fixed routines or from living with multiple people who have different routines or preferences.

*"How does it handle an unpredictable everyday life? My routines are exactly the same, but last week I was sick and didn't need an alarm clock. Then there should be a control system I have implemented. Should I design a routine or should the system follow me? How does it adapt to disruptions in routines?" –P4*

*"I want to understand what it wants to do. It's scary when you don't understand why it wants to do something, or what it's doing." –P9*

### The differences in the participants' living situations and their care for adjusting the home atmosphere clearly affected their responses and attitudes toward the prototypes and their perceived value.

There was a clear difference in the perceived value of the solution when you compare the reactions from participants with different living conditions. Those living a busy student life and have flatmates with different preferences questioned how well a "magical" entity controlling their home atmosphere would work.

*"Life situation matters. We are not at home much, so it will take longer to learn our habits. I don't know how much patience I would have in an already busy everyday life to deal with yet another thing." –P10*

*"It's probably not the thing for collective housing, people who come and go a lot, with a tight economy. But for more established homes, it is more relevant." –P7*

The married participant, however, was more open to the idea and connects the unpredictability of an autonomous agent to its potential to shake up the atmosphere in a family with kids.

*"From a family perspective, [unpredictability] could be very fun. It could change a bad mood into something fun, like if it suddenly changes to party mode. Then everyone's mood would improve." –P1*

Another emerging factor was the wide range of sensitivity to the home atmosphere and the attention to adjusting it with lights. This also affected the perceived value of the intelligent system.

*"The motivation depends on how much you would gain from it. If it's only about dimming the lights when watching a movie, it's limited. I just need light, it's a bit individual." –P6*

*"I'm not good at setting the mood, but I really appreciate it when people do it. For example, 'when you put on a movie, then I dim the lights'. I'm very positive about the atmosphere, but it's something I don't want to do myself." –P5*

### Thoughts on home technology that can learn

Taking part in the AI's learning process might make people feel more familiar with it, and thus less creeped out when it starts acting on its own accord. The motivation to teach the intelligent agent and the patience to let it learn is tightly coupled with its perceived value. One participant proposed a passive learning mode, where the artifact would act as a one-way interface until it has been properly taught.

*"It would be less scary if I could see it learning gradually, and if I somewhat understood what kind of information it has. Why it does what it does." –P9*

*"It depends on the usefulness I would get out of [teaching it]. I don't know if I think this is something I need in life, it would rather be annoying to have to teach it. It's very okay to be able to make these choices myself." –P4*

*"Maybe it wouldn't do anything while you're teaching it, but as it gets better, it starts doing things. So that you can see that it's getting smarter and smarter." –P7*

The complexity of co-living was mentioned by four participants – who does it mainly learn from, and whose data will dominate its knowledge?

*"The problem is that it learns from two different people. If there are multiple sensors, it can detect the number of people in the apartment or who is in the apartment – if both mobile phones are nearby, are both present?" –P8*

**People's openness to automation and suggestions from an autonomous agent, as well as how they perceive nudges, are determined by a complex set of factors related to their current context, mood, and the probability and impact of errors.**

People's current context affects their tolerance for nudges from the autonomous agent. Influential factors are the time of day, the social context (home alone or having guests over), and their current activity.

*"It's great that it asks for permission, considering that you need to be in the right mood. It's nice that I can block it until I'm ready for it." –P8*

*"Is it okay to lock this [parameter] out as well? To make sure that nothing weird will happen when I have people visiting." –P9*

Another major factor is the probability and impact of errors caused by misinterpretations of the situation.

*"I think it would take me some time to realize that it was making the right changes. The first time it enters party mode, it would be very fun, but it becomes annoying when it happens at the wrong time. If it is smart enough to do it at the right time, it would be a good thing. But what if it tells me to study, and I don't want to?" –P9*

*"With lights, it doesn't matter that much if it makes mistakes, then it's easier to trust it. The less significance an error has, the easier it is." –P3*

Participants related this risk of errors to their perceived limitations of technology, doubting that the intelligent agent would be able to interpret and predict the complexity of their lives, social dynamics, and minor nuances in moods and routines.

*"To match a mood or try to boost a mood, if one is happy the mood should not be brought down, but if one hasn't slept well and just wants a dark room it might be okay with a little push to get going. At the same time, it should be okay to have a bad day every now and then." –P8*

*"I used to live with someone who wanted it to be dark all the time. I wanted it to be bright. That would have been difficult for this thing to understand." –P9*

One participant expressed a need for a correlation between their current openness to changes and the frequency of changes. Two participants suggested a parameter to control the agent's degree of freedom.

*"I suggest one [parameter] that controls how much freedom it has, that one parameter is the frequency of suggestions and [AI] training you want. If it is high we are open to training it. If it is low it follows the thing that it already has learned." –P2*



Four participants prefer the simplicity of not having to make decisions or “deal” with things. Six want to make fine-grained adjustments and set boundaries for the intelligent agent.

When comparing the two prototypes, four participants saw advantages of the prototype that makes decisions for you; in a routine-bound and predictable lifestyle, they prefer full automation, rather than having to accept a proposition. One stated that being able to correct the agent would give them sufficient control.

*“Having to say yes or no to a suggestion every time seems a bit cumbersome. Then I could might as well just turn on the light myself.” –P4*

*“I would choose that things just happen. [...] I can trust that it makes a decision, and correct it afterward, as long as it’s easy to correct.” –P5*

The other six participants preferred the second prototype, as they wanted to limit the agency of the “magical” agent and set rules for what it could do, or because they wanted to customize the atmosphere by tweaking different parameters rather than just switching between modes.

*“To a full extent, I would have wanted it to make adjustments [on its own], with me being able to choose what it controls. I could let it control the lights and sounds. But I wouldn’t trust it enough to control other things.” –P3*

*“It’s fun to think of an equilibrium. And then there’s a degree of partying, from calm parties to techno parties. Every [parameter] has its levels. A mode within a mode.” –P7*

The perceived value of a tangible user interface

Five participants stated that they appreciated the simplicity and potential aesthetic qualities of a physical object. One said that the physicality made the notion of their home being controlled by an autonomous agent less uncomfortable. One stated that even though one might expect less functionality from a TUI than from an app, the limited functionality is more adapted to a home context.

*“[I imagine something with] really smooth movements, almost satisfying, seeing that it’s thinking or working on something: ‘Oh, now it’s right, now it’s doing what it’s supposed to do.’” –P7*

*“It becomes a little less scary because it’s a physical and friendly thing, that you’re not just typing things in.” –P9*

*“It’s nice to have a physical interface because it’s simple. In an app, there’s so much you can do. But a simple interface that blends in with the home is much easier. In an app, I would expect to be able to do much more.” –P8*

However, four participants suggested that a physical object would work best when supplemented with an app.

*“It’s cool to have a physical interface, I’m a fan of having a control center for lights. But it’s not always the patience to get up and cross the room is there.” –P8*

*“On mobile devices, there is much more room for parameters. You would probably need both. However, a physical object becomes a part of the room and the house.” –P7*

### 4.3.4 Limitations and Considerations

**The design of the prototypes vary a lot in their level of complexity, abstraction, and form factor.**

The functional prototype was clunky and limited to the modes that we defined. Configuring such modes is highly individual, and the modes we included may have influenced the feedback sessions. During discussions, the participants often referenced modes from the functional prototype such as “cozy”, “party”, and “morning”. However, evaluating the usefulness of the concept based on whether people would want these specific modes in their homes, and by the light and sound settings we chose for these modes, may be a potential issue.

On the other hand, the second prototype was highly conceptual, making the connection between the home and the prototype very abstract. We did not label any of the parameters, which resulted in discussions where they were interpreted as either “general” parameters such as light, temperature, and music mood, or different scenes, where the parameter was seen as the intensity of a certain scene. The layout of the second prototype, with its independent walls and sliders, also made it more complex. The difference in appearance between the prototypes seemed to make it difficult for people to discern exactly what separated them in terms of functionality. As our main objective with the feedback session was to explore which degree of agency of control people preferred, this was somewhat obscured by the differences in appearance.

In addition, the unfinished look of our prototypes made it difficult to convey our aesthetic motivations for the interface. We had elaborate visions for the aesthetic values of these concepts, such as using the sound of stone slowly turning or moving to ambiently communicate state changes. However, these aesthetic properties were not present in the prototypes, which understandably

resulted in a discussion primarily focused on functionality.

**Our plan to test how physical manifestations of intelligent agents convey the idea of communicating with them and limiting their agency was overshadowed by real-world, practical concerns.**

Although tangible prototypes helped to concretize discussions around intelligent, proactive automation, the complex practicalities of building such a system made it difficult to focus on assessing how people experience interacting with an intelligent agent with a physical form. Testing abstract principles like these might be more successful if not paired with such a complex task as automating and parametrizing the home atmosphere.

**There is a large spread in the results, which, in addition to the aforementioned points, might be attributed to the participants’ life situations.**

The results indicate a correlation between participants’ life situations and their attitudes toward smart home concepts. However, due to the small number of test participants and the broad diversity within groups, each group was sparsely represented, especially people with more established homes. To address this issue, it seems sensible to target this demographic further on in the project, as the results suggest that these solutions may resonate most strongly with them.

Conversely, participants living in shared accommodations showed limited interest and struggled to imagine how this technology would integrate into a more established home setting. Their perspectives were, naturally, influenced by their present circumstances, where their connection to their living environment is not as strong.

## 4.3.5 Discussion

### **How did people experience having an all-knowing entity in their homes?**

Our findings suggest that people may dislike having an omniscient AI in their house due to the creepy sensation caused by the uncertainty of why actions are triggered and the fear that it might not completely understand them and make mistakes. However, when the AI's decisions are correct, they appreciate the simplicity of things being done for them, and the smart home's ability to remind or suggest ambient lighting for quality time.

### **The Creepiness of AI's Opaque Reasoning**

We hypothesized that showing the current state of the room physically and having entities move when the agent's state changes would sufficiently convey the intent of the smart home, making it less scary. However, the fact that our current interview results match the results from the initial workshops, suggests that although the physical object conveys what the smart home wants to do, the uncomfortable sensation remains due to the lack of transparency as to why the smart home makes these changes. The black-box nature of AI makes it inherently difficult to explain its reasoning; moving its interface from the screen to the physical world does not change this.

Additionally, while it was not a primary focus during the feedback sessions, the core idea of ubiquitous data collection in homes raises several ethical concerns. Even with a well-intentioned company offering this service, processing data locally, the risk of software vulnerabilities in internet-connected devices being exploited to access private information remains. Effective personal automation AI may require substantial amounts of data, and the potential exposure of such information presents significant privacy issues.

### **Mitigating people's mistrust towards domestic AI**

The participants varying perceptions of the prototypes' value can be understood by the earlier mentioned finding of Brush et. al. (2011): users appraise the value of automation based on the impact of a wrong system decision, the chance of the system making mistakes, and the perceived value of the automation itself. People are less open to automation when they don't trust that AI can accurately interpret social dynamics, and nuances in moods and routines. Furthermore, the perceived cost of mistakes is context-dependent. One participant expressed an increased cost of unwanted changes when having visitors over, due to the possible judgment from friends.

We envision four ways to mitigate AI's shortcomings which leverage the human strength of interpreting social dynamics: (1) automations that relies on user-defined rules as a framework and further adapts based on user input over time, (2) using prototypes as traditional interfaces until they reach sufficient training levels, drawing inspiration from house plant care, a pet or even Tamagotchi to make teaching more motivating, (3) providing the AI system with cues that make it easier to interpret the current context, for examples using tokens for different moods or social settings, and (4) allowing users to adjust the AI's degree of freedom at any moment, for example through a slider.

### **To what degree do people want to limit the agent's ability to make changes?**

By comparing the two prototypes, we wanted to investigate to what degree people want to be able to limit an intelligent agent in the home. However, on this matter our results were inconclusive, we had participants who described the second prototype as "cumbersome", and preferred the simplicity of things just happening, while others established the importance of being able to limit what the agent could control.

We can conclude that the desire to restrict an autonomous agent varies based on individual preferences, but that it should be taken into consideration. Users felt uneasy about why actions are triggered and were concerned about potential mistakes, thus, it seems unlikely that a completely autonomous agent for controlling lights in a smart home would be desirable to the general public.

### **Main takeaways**

The pluralistic, and sometimes contradictory, findings of our interviews were confusing, but they have also led to some important insights about the value of physical interfaces and automation, suggestions, user groups, and realistic product scoping.

While the simplicity and glanceability of a physical interface were appreciated, the complexity of its actions makes it difficult to envision a physical entity that is flexible enough. The tests show that a physical object is unsuitable for handling a lot of complexity and that its interface is too limited to convey its learning, intentions and proposed actions. Considering the suggested steps of improvement, the product does not fully utilize its physical nature by complementing digital modalities but rather appears as a digital service forced into a physical object.

Going forward we wish to use the strengths of automated actions, rather than envisioning an agent with human-like abilities. We will look for a simple solution that allow humans to utilize their ability to understanding context and their own preferences, while the agent work as a reminder rather than an autonomous executor. We raise the question if an AI is really necessary, or if time- or sensor-based triggering might be sufficient to nudge the user. There is a balance to be found between making a product that makes surprising suggestions to the user, without it being cryptic and incomprehensible.

We see a need to specify our user group. The result was clearly affected by having numerous students living in shared flats as the main part of the selection. Going forward we aim to focus on users living in more established homes, as they might have a stronger sense of care towards adjusting their homes to their liking.

In further user tests, we also want to consider interaction aesthetics. Our goal is to create a product that holds emotional value in its interaction aesthetics, so these properties should be present in further prototypes. We should also encourage users to describe their experience from an emotional point of view, rather than merely in terms of convenience and practical value.

## 4.4 Reflecting on Designing with Magic

### **The use of animation magic in a physical product helped people discuss agency and boundaries for an autonomous agent in the home.**

Adding animation magic to a physical product enabled discussions about agency and boundaries for an autonomous agent in the home. We believe that manipulating physical barriers, as in the second prototype, helped people visualize and understand the concept of setting boundaries for the agent. This is demonstrated in their use of words such as “blocking” or “locking out” a parameter:

*“It’s great that it asks for permission, considering that you need to be in the right mood. It’s nice that I can block it until I’m ready for it.” –P8*

*“Is it okay to lock this [parameter] out as well? To make sure that nothing weird will happen when I have people visiting.” –P9*

Moving objects to show a state, as in both prototypes, might have made it easier to relate to and talk about the concept of agency. The first prototype, however, better conveyed device agency as the pointing was moving on its own. With the second prototype, people tended to focus more on user agency by expressing their own preferences in adjusting parameters.

### **Magic as a metaphor for AI might do more harm than good.**

Artificial Intelligence is undoubtedly going to revolutionize many aspects of our lives, and as designers, we have to engage with how such technology is presented to people in a way that makes it understandable, and useful. However, it is important to understand the true impact of this revolution. In a recent article in the Norwegian newspaper *Morgenbladet*, Dag Mostuen Grytli urges us to divest ourselves of the notion of AI as

a magical, otherworldly force with superhuman intelligence. Instead, we should shift our focus onto the human and power dynamics that are inherent to its development and deployment (Grytli, 2023).

His argument is that an almost religious fascination for what AI might do in the future distracts us from the discussion about the human and planetary cost of the vast infrastructure that underpins the creation of these large AI models. AI is not magic – it is a corporate machine spanning from hazardous working conditions in mines, to huge centers of workers classifying data for AI training sets, and huge server centers with an astronomical consumption of electricity. This is shown well in the elaborate figure below, *The Anatomy of AI* by Kate Crawford and Vladan Joler (2018). It is a cradle-to-cradle map of the life of an Amazon Echo, a little smart speaker which to many is the face of AI.

Therefore, a danger of connecting magic to technology might be uncritical technology optimism, which we ironically sought to counter in this project. We wanted to leverage magic’s close connection to human stories and culture to build something human-centric. However, humans have flaws, one of which might be blinding fascination for what we don’t understand, and things that exhibit human-like traits. It might even be possible to make the argument that the name “artificial intelligence”, and “general artificial intelligence” and “sentient AI” in particular, expresses some of Subbotsky’s ‘magical belief’ – the idea that some humanly created entity will come to life and have a mind of its own bears a clear likeness to the concept of animacy and animation magic.

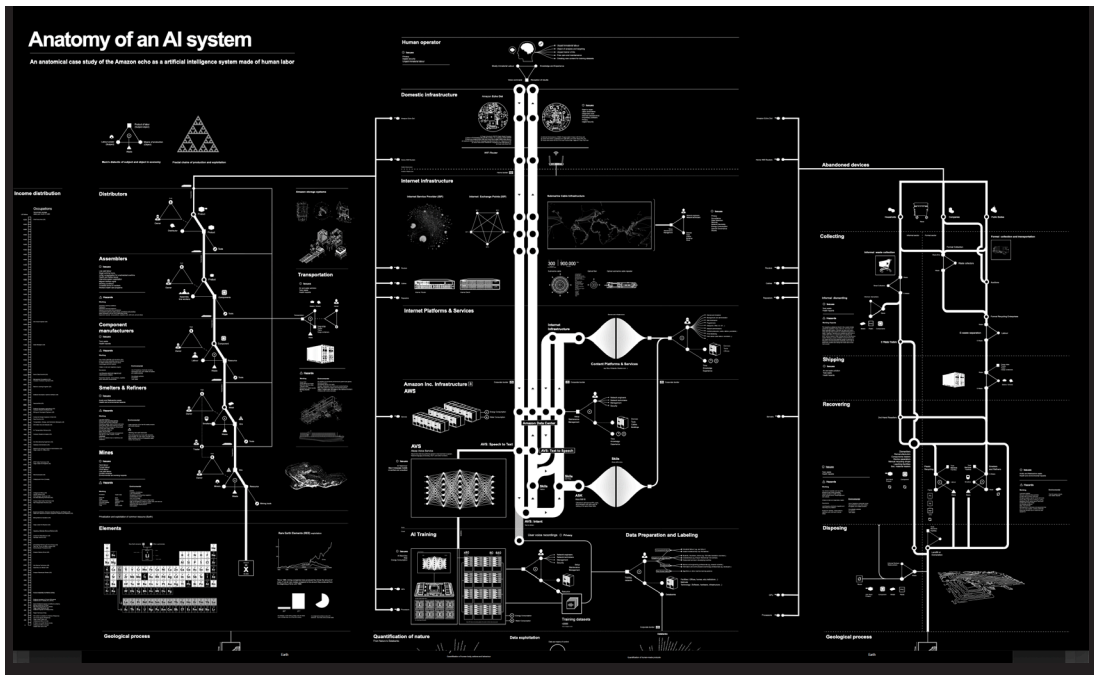


Figure 4.2: The Anatomy of an AI system  
(Crawford & Joler, 2018)

Bender et al. (2021) cautioned against our tendency to assign meaning to the meaningless in their article about the dangers of large language models (LLMs), calling them stochastic parrots due to their purely statistical way of building sentences: "The problem is, if one side of the communication does not have meaning, then the comprehension of the implicit meaning is an illusion arising from our singular human understanding of language (independent of the model)" (Bender et al., 2021, p. 616).

This warning is exemplified in a recent New York Times article, where the tech columnist Kevin Roose shared his interactions with Microsoft's Bing browser's new ChatGPT-powered bot:

*"These A.I. models hallucinate, and make up emotions where none really exist. But so do humans. And for a few hours Tuesday night, I felt a strange new emotion — a foreboding feeling that A.I. had crossed a threshold, and that the world would never be the same."* (Roose, 2023)

While we should be careful with likening AI to magic, infusing AI with some of the qualities of enchanted objects is not necessarily bad. The calm and ambient traits of the intelligent magical objects featured in our background chapter could provide more pleasurable and meaningful interactions with AI, given that we frame it correctly: We must strive for a balance between magic and machine, where AI is not feared as a mysterious and uncontrollable entity, but rather seen as a tool designed and controlled by humans, with all our strengths and flaws.







# Magical Metaphors and Smart Home Rituals

Throughout the prototyping and user testing of the dialogue prototypes in Chapter 4, we learned valuable lessons on automation and the desire for user control. We gained insights into the degree to which people want intelligent agents to act autonomously or only make suggestions. However, we concluded that the determining factors are highly complex. Addressing all the user needs we identified would result in something resembling a smartphone. Creating something that allows people to adjust all parameters, create scenes, make rules, and provide information about their current context appeared to be outside the project scope of envisioning more aesthetic interactions.

As this is an explorative project, it made sense to take a step off the path that we started going down and explore another possible direction that emerged from the initial workshops. The direction of rituals where the interaction is strongly connected to the effect, is more in line with bringing magic into the smart home domain.

We wished to pursue the idea of creating a simple artifact that builds a ritual around the interaction for inducing a cozy light atmosphere. As suggested by Van Campenhout, et al. (2016), physical and digital integration can be optimally balanced in products that are dedicated to one main task, as opposed to touch screens that are suited for doing multiple tasks. We have found that people are not bad at turning on the light that

they need, but many forget to set the lights in a certain way when they want to enjoy themselves. Therefore, we aimed to make something that reminds people that they want a cozy atmosphere and makes it easy to initiate one. For the same reasons we also decided to focus only on light control and exclude music from being part of the atmospheric changes going forward.

The object should be inspired by magic and fit naturally into the home environment, which should be reflected in its materials, behavior, and interaction qualities. Our workshop participants suggested natural materials for their aesthetic appeal and connection to magical stories and lore. An element of unpredictability could also assist in creating the feeling of a magical object and a home that has a life of its own, as this was something several participants mentioned in the workshops.

In short, we want to explore aesthetic connections between emotionally motivated actions and their effects, while bringing with us the lessons we learned on automation and user control. We will look for metaphors from magic to inspire this interaction, as the world of magic holds many objects and actions with emotional values.

## 5.1 User Groups



Image 5.1: Young people in shared housing.



Image 5.2: Families with children.



Image 5.3: People living in more established homes.

In the previous round of user testing, we saw a clear correlation between the participants' living situation and the value they saw in help with setting the home atmosphere. The biggest contrast was between those living in more established homes and those living in shared housing.

Additionally, the two participants who had children saw other uses for the concepts than those without. Therefore, in this exploration we will focus on people living in more established homes, either with or without children.

## 5.2 Mapping out Metaphors

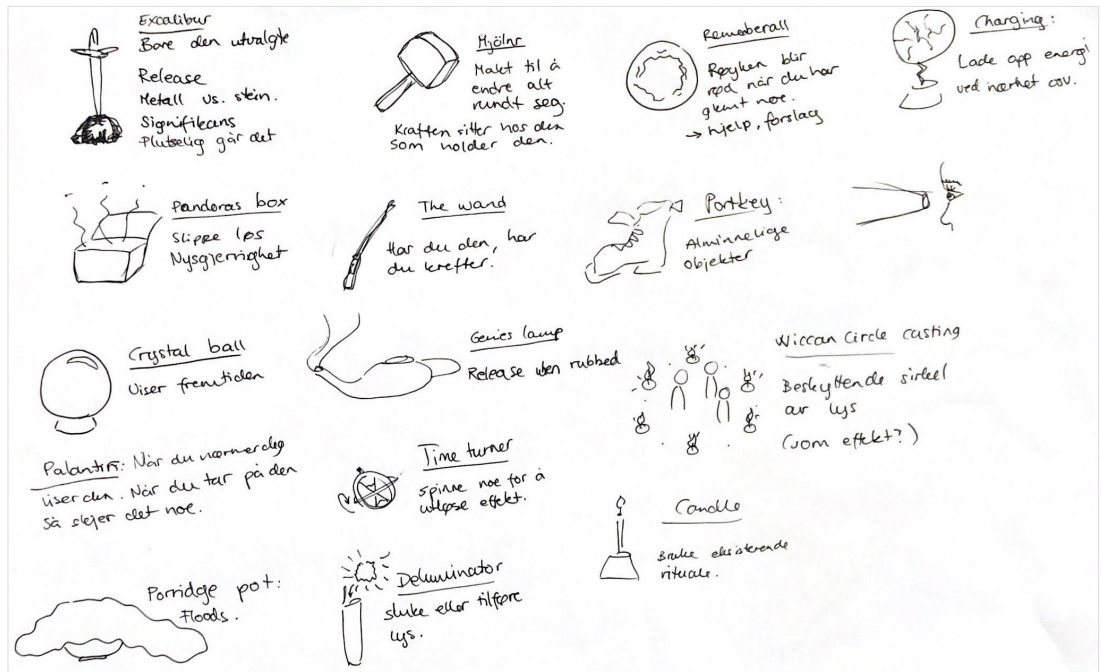


Image 5.4: The short list of magical metaphor candidates.

Looking to magic for sources for metaphors, we mapped out existing magical objects from popular culture, mythology, and folklore and the metaphors that could be derived from them. We used ChatGPT 4 to generate a list of magical artifacts supplementing the ones we knew of already (OpenAI, 2023). We double-checked the results to mitigate its tendency to bring its own fabrications into such lists. To evaluate the objects' suitability as sources for the metaphor, they were analyzed based on whether they inherit the qualities we had in mind, such as releasing light or energy, initiate an effect, make suggestions, or give people the sensation of possessing magical abilities. This resulted in a short list of candidates (Image 5.4).

The list of 26 objects generated with ChatGPT 4 can be found in Appendix G.

Next, we explored how well suited these sources of metaphors were for being mapped to the target object we had in mind: an interface intended to help remind users to adjust their lighting to create a cozy atmosphere in a simple and aesthetically pleasing way. The list of potential sources was then narrowed down to the salient examples of their category, to make sure they communicated their meaning as clearly as possible, as suggested by Glucksberg & Haught (2006). We also considered how related they were to our target objects, as there is a higher potential for building meaningful metaphors if the source and the target have some similarities (Cila, 2013).

Based on these considerations, the most suited metaphors for our objective were:

- Pandora's box: Although we do not want to release all evil in the world, as in the greek myth (Pandora's box, n.d.), the metaphor could be used for a box containing the suggested atmosphere of the room. We envisioned that one could preview the light color and intensity by making the box translucent. Curiosity is what drives Pandora to open the box, and we envisioned that the box could aim to trigger the user's curiosity.
- Neville Longbottom's Rememberall, that appears in the Harry Potter series (Rowling, 1999) is a portable glass ball that emits red smoke when its owner has forgotten something. This object exists solely to remind people that they have forgotten something. Similarly, we want to create a simple object that exists solely to remind people to turn on cozy lights in their living room in a subtle way.
- Crystal ball: This artifact is used in numerous stories for seeing the future. The metaphor could be leveraged by having a ball that previews a certain atmosphere before the user induces it. The Palantir featured in The Lord of the Rings (Tolkien, 1991) is an example of such a crystal ball, which comes alive when someone puts their hands on it. The act of putting your hand on a glass orb was appealing to us as an aesthetic interaction.
- Wiccan circle casting: A protective circle cast around you to form a sacred space (Magic circle, n.d.). We connected this to the effect that could appear as the user releases an atmosphere into the room - as the lamps light up one by one, your home becomes a safe space. We draw a parallel to Dumbledore's hand gesture which lights candles around the walls of the dining room in Harry Potter.

We continued by taking the metaphors apart to see if we could use them in a way that did not copy the object directly, but rather used just enough from the metaphor to make the interaction understandable. As stated by Cila (2013), infusing the target with the "essence" of the source is a more elaborate strategy than literal mapping of properties.

Firstly, regarding the metaphor of Pandora's box, we appreciate the reference to releasing something into the world, but as the current term is mostly used for something better left untouched for fear of what might come out (C, 2021), the metaphor was not suited for an interaction. The essence of Neville's Rememberall is to be a reminder, this salient property was highly relevant to us, and something we wanted to incorporate in our target object. The crystal ball's prominent property of being a fortune teller makes it a suited metaphor, as we want to provide users with a preview of what their lighting may look like. From the Palantir we want to incorporate its ability to initiate an effect when being touched. Wiccan circle casting is more of a secondary source for further development, but might serve as inspiration for the effect that is induced by the interface.

We concluded that combining these interaction qualities of the Rememberall and crystal ball/ Palantir into a metaphor, was best suited for our idea of a physical object that will help people remember to set a cozy atmosphere. We decided to transfer the sphere shape of the crystal ball and Rememberall to our product. It is a form factor that is shared between our metaphor sources, the spheric shape will help the product stay true to the metaphor and make it easily interpretable. The spherical shape also stands as a statement against "the world of glass slabs", as described by David Rose, where he challenges the flat screens that dominate our everyday life. The spaciousness and three-dimensionality of the sphere contrast the two-dimensional interfaces offered by conventional touchscreens.

## 5.3 Final Concept: The Crystal Ball



We envision that the orb will slowly and subtly start lighting up (like Neville's Rememberall) as a discreet reminder to create an ambient atmosphere. Inspired by calm technology, the orb will stay in the background for most of the day, and when it provides a suggestion, it will be unobtrusive, staying in the periphery. The suggestion will be given at an unknown time, introducing an element of unpredictability.

The envisioned interaction is illustrated in Image 5.5. The ball will light up with the same color combination as that of the atmospheric light that it suggests (showing the potential future, like a crystal ball). The suggested light setting will be different each time, which builds upon the element of unpredictability. Unpredictability aligns with participants' association with a magical

aesthetic, and the de Jongh Hepworth's (2007) principles of a magical experience.

The user will only have the option to accept or deny this suggestion. Our aim is that a curated suggestion with no options for adjusting parameters makes the interaction feel more organic and magical, rather than digital. Leaving out options of tweaking and having a "what you see is what you get" approach is a step away from where smart home technology stands today.

If the user chooses to accept the change of lighting, they can carefully put their hand on the orb (like one would with a Palantir) to induce a transformation from the original state of the room into the suggested lighting.

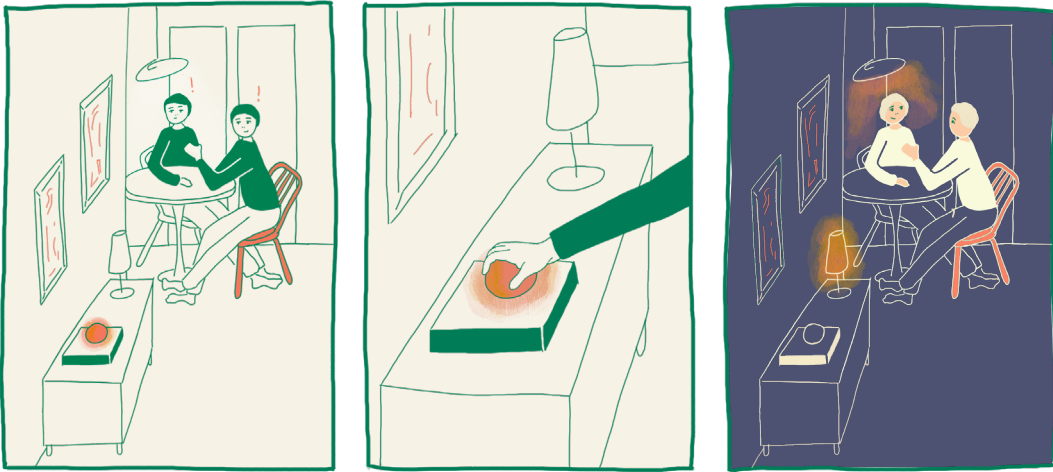


Image 5.5: Scenario of use for the crystal ball.

This is a simpler solution that is mainly emotionally and aesthetically motivated, however, some practical questions arose:

- What is a cozy atmosphere? Should this be defined by the user, curated by a designer, or by an AI?
- How is it adapted to each individual home? Should the user define what lamps they like to use for a cozy atmosphere? Should the color of the lights be adapted to the colors of the walls?
- When should the orb light up? Should it use light sensors to determine if the user should adjust their lights? Should the user define a time interval where they are open to suggestions?

While our previous explorations helped to inform these topics, they were also important in the following user tests and interviews. The goal was to determine where the product should be placed on the scale between user input and curation.

## 5.4 Prototyping

From the previous round of user testing we learned that for aesthetically motivated concepts, the prototype should inherit the aesthetic properties we envision, to avoid user feedback that only revolves around convenience and practicalities. Furthermore, we were motivated by high quality prototype, encompassing the values and aspects of magic studied in the thesis.

### 5.4.1 Designing and Illuminating the Orb

Light is unpredictable, and designing with light requires an experimental approach. Our first experiments concerned ways of lighting up glass objects that varied in shape and texture. We used different-sized LED rings to light up an empty, frosted light bulb (Image 5.6), a solid glass marble (Image 5.7), and a clear light bulb filled with oil (Image 5.8) to simulate a solid glass object, as oil has nearly the same refractive index as glass.

Despite having a slightly more technological look than the other two, we appreciated that the frosted light bulb was able to display several colors at the same time, which would be of importance if the suggested light atmosphere contains multiple colors. The clear bulb filled with oil turned out to be a bad indicator of the light refraction in a solid glass orb, because the light was refracted in the oil's surface membrane. From this experiment, we preferred the "non-technological" look of the marble, but it was quite small (30 mm in diameter) so we were curious to experiment with a bigger, solid glass orb.



Image 5.6: Frosted light bulb

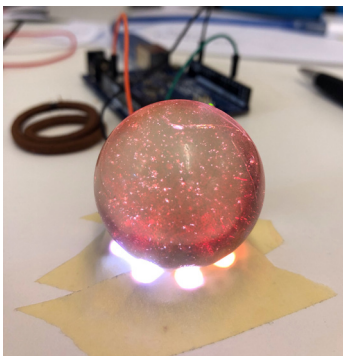


Image 5.7: Glass marble



Image 5.8: Light bulb filled with clear oil

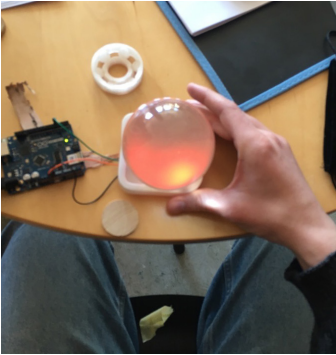


Image 5.9: Diffusing the light with Corian



Image 5.10: Light refraction in a clear glass ball

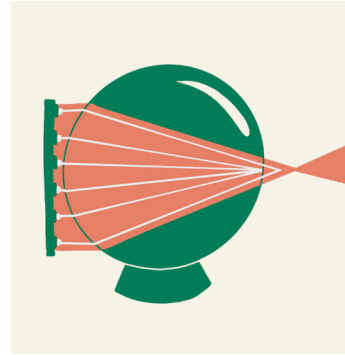


Image 5.11: How light is refracted in spherical objects



Image 5.12: Frosting the orb



Image 5.13: Light catching the frosted part of the orb



Image 5.14: The orb when frosted completely

Our next experiment was with light refraction in an 80mm, clear, solid, glass orb. We tested different levels of light diffusion by illuminating it through various materials such as paper, white PLA, and Corian (Image 5.9). From this experiment, we concluded that the main challenge was the properties of light refraction in a sphere. It works as a lens that directs all light rays toward the opposite surface point, which makes the light and color nearly invisible in the sphere itself (Image 5.10 and Image 5.11). We tried frosting parts of the orb to refract the light before it entered the orb (Image 5.12), but with little success. However, the frosted part was able to "catch" the light when placed on the opposite side of the light source (Image 5.13).

Since the frosted surface was able to display light and color in a satisfying way we decided to frost the orb completely (Image 5.14). Although this look was more similar to the "technological" look of the frosted light bulb than first intended, the massiveness and weight of the orb still provided an analog feel.

We were satisfied with the look of the frosted orb, but the frosting spray is made of polymer, giving it a plastic-like texture, in addition to making it very scratch-prone. We decided to have it sandblasted for a more authentic, quality finish.





Image 5.15: Rectangular base



Image 5.16: Square base



Image 5.17: 3D printed replica of the wooden base

## 5.4.2 Designing the Base

The orb also needed a base that would contain a small Arduino and LEDs, and for this we tested a few different shapes (Image 5.15 and Image 5.16). We went with a square base to align with the sphere symmetry. In addition, we hoped that a flat surface would underpin the circularity of the sphere. As using a spheric shape was already a quite literal reference to our metaphor, we wanted to avoid directly mimicking the base of a crystal ball, which might appear gimmicky and trivial. Therefore, we aimed to create a base that had a stronger connection to the home context and the target as an interior object.

Regarding the material of the base, wood, stone, and concrete were some of the alternatives that we considered. However, we concluded that wood was the most aesthetic option as it appears as a soft and warm contrast to the cold and hard glass sphere. Wood also counterbalances the “technological” look of the frosted sphere to give the finished composition a more analog feel. It is also feasible to make using CNC milling, and it suits the home context.

To ensure sufficient thickness of wood, while still making space for the electronics, we 3D printed a replica of the finished model, to test the dimensions prior to milling the finished product (Image 5.17).



Image 5.18: CNC cut of the electronics compartment.



Image 5.19: CNC cut of the recess holding the orb



Image 5.20: Fiber optic cylinders to enhance to orb lighting.

For the type of wood, we had access to materials that had been stored for more than ten years at the university workshop. We used a piece of leftover mahogany, for its warm and red color tone, as well as its hardness and sturdiness. We must emphasize, however, that if this project is to be recreated we do not recommend using mahogany. Mahogany grows slowly, and like other types of rainforest timber it is often illegally harvested, contributing to deforestation of rainforests. Oak or elm would be good alternatives.

After milling (Image 5.18 and Image 5.19), the piece was cut to a 16x16 cm square and lightly sanded to ensure a smooth surface. The holes for the LEDs had to be hand-drilled, but we marked them out using the CNC to ensure even spacing.

In order to protect the wood from marks and dirt, we experimented with different surface treatments. Clear hard wax oil significantly darkened the wood, particularly on the end grain, while soap washing could potentially warp the thin wooden walls. Therefore, we decided to leave the prototype untreated for the purposes of this project. However, for long-term use, surface treatment is advisable to prevent finger marks and other forms of wear and tear.

During testing, we were not satisfied with the amount of light emitted from the frosted orb when adding lights to the wooden base. The thickness of the base caused the LEDs to be placed further away from the orb, and the dark wood absorbed some of the light. By placing small fiber optic acrylic cylinders in the holes we were able to lead the light more directly to the orb, but it was only a minor improvement (Image 5.20). We scoured the market for brighter individually addressable lights, finally finding 3A LEDs that were significantly brighter than the 0.2A LEDs we had been using.

Although they were brighter, they did not animate smoothly in terms of brightness and color, and as we were faced with a decision between a bright glowing orb, or smooth animations, we concluded that it is easier to darken the surroundings, than making the animations seem smoother than they are. We therefore continued using the 0.2A LEDs.

Finally, the LEDs and the microcontroller were fixed to the wooden base using a glue gun (Image 5.21), and a plywood lid was screwed on (Image 5.22).

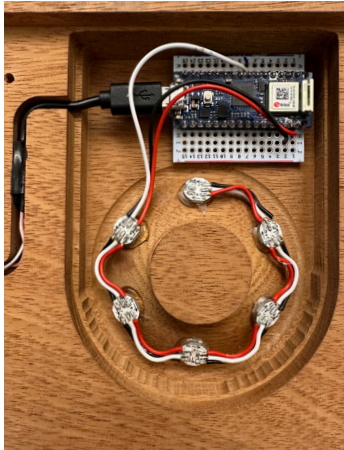


Image 5.21: The mounted LEDs and microcontroller



Image 5.22: The bottom lid

### 5.4.3 Light Animation

We developed the orb's light animation continuously throughout the prototyping process, to find a balance between subtlety and noticeability. The final animation is a combination of individual, gradual changes in brightness for each LED and a consistent rotation of the colors around the LED loop. This allows for viewing all suggested colors from one angle, as well as a variation in the overall hue of the orb.

A core idea of the concept was that the orb would glow with the color combination of the light setting that would appear in the room. Using a smart-home setup with lamps in a dark room, we decided on two color palettes to illustrate this point, one with warm tones of yellow and red, and one with more vibrant colors, and implemented correlating colors in the orb.

When the orb is touched, the lamps in the room dim down, and the orb starts glowing more intensely. One by one, in a random order, the lamps slowly fade back in with the colors presented in the orb. To give the impression that the lights inside the orb are released into the room, and help clarify the metaphor to the user, the lights of the orb fade out one by one, as each light in the room fades in. Once all the lamps are faded in, slow variations in brightness for the individual lamps will start.

This choreography is quite slow, including gradual dimming of the lights and a delay before they fade back in. Once they do it takes more than a second for each light. The fact that it takes time contributes to the theatricals and anticipation that constitutes a ritual, as opposed to controlling lights for everyday use. This is inspired by the carefully choreographed interactions by Bang & Olufsen and de Jongh Hepworth's (2007) principles of magical experiences.

## 5.5 The Final Prototype





This is the crystal ball, comprising of a wooden base and a solid glass orb.



Some time in the evening, the ball will slowly start glowing, presenting a combination of colors it suggests for the lamps in your living room.



If you want the suggestion, place your hand on the crystal ball. This will make ball glow more intensely, all the lamps in the room will dim down.



The lights from the crystal ball will one by one transfer to the lamps in the room.



When all lamps are faded in, their individual brightnesses will vary subtly in a slow, organic motion.

### Interaction demo



The full interaction sequence can be seen in the submitted video attachment, or via this Youtube link:

<https://youtu.be/Nx-g74oqBB4>

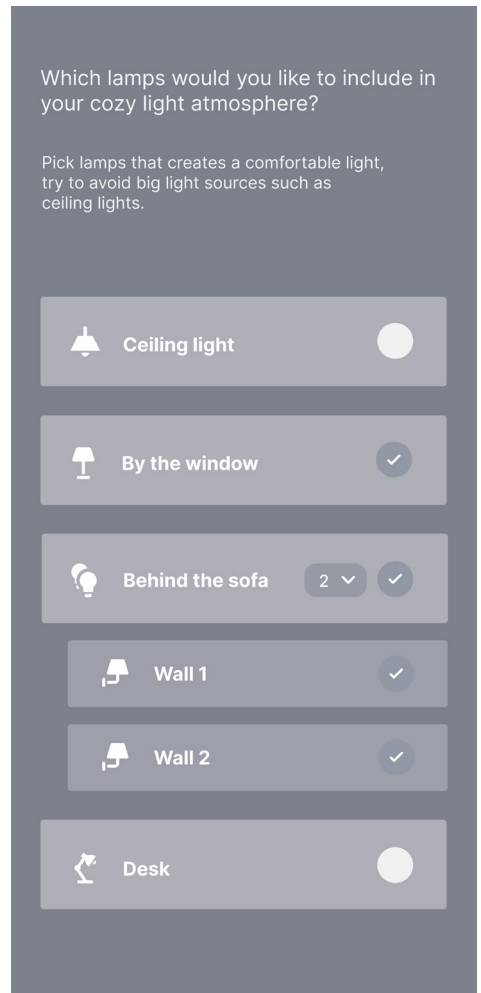
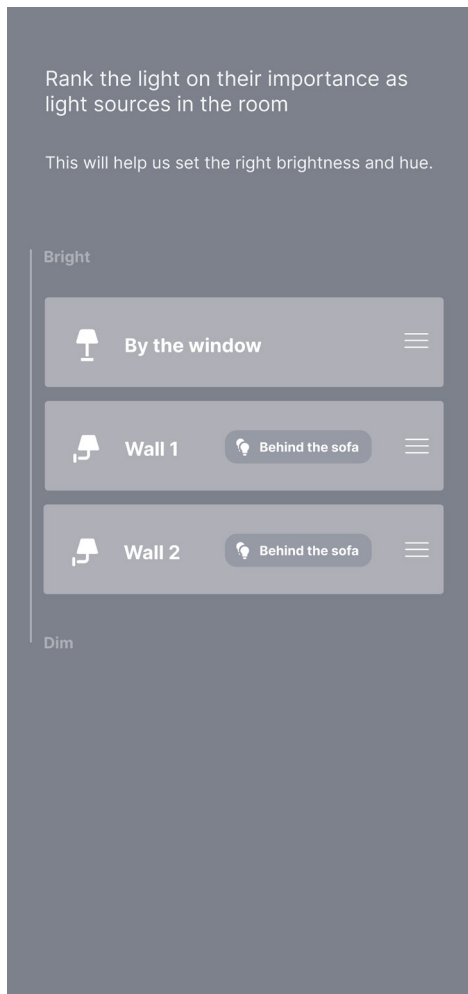
### 5.5.1 Wireframe Sketches for the Product Setup

Although this concept is centered around the experience of the interaction, we saw a need to address its adaptability if it were to become a product in “the real world”. Throughout the process, we tried to answer the question “What is a cozy atmosphere?”. Although a general assumption is that warmer, dimmed lights are preferred, it is still a matter of individual preferences. Secondly, all homes are decorated and lit differently, the specific lamps that are being used can greatly affect the feeling of the atmosphere. Lastly, we have envisioned that the ball will start glowing at some point of time during the evening, but people have different routines and needs; when should the ball start glowing?

To account for this need for adaptability, while maintaining our idea of curation and unpredictability, we created sketches for what a setup of the ball could look like. Our hypothesis was that allowing the user to express their preference once during the setup (with the option of going back in later), eliminates the need for making real-time adjustments when the mood is being initiated.

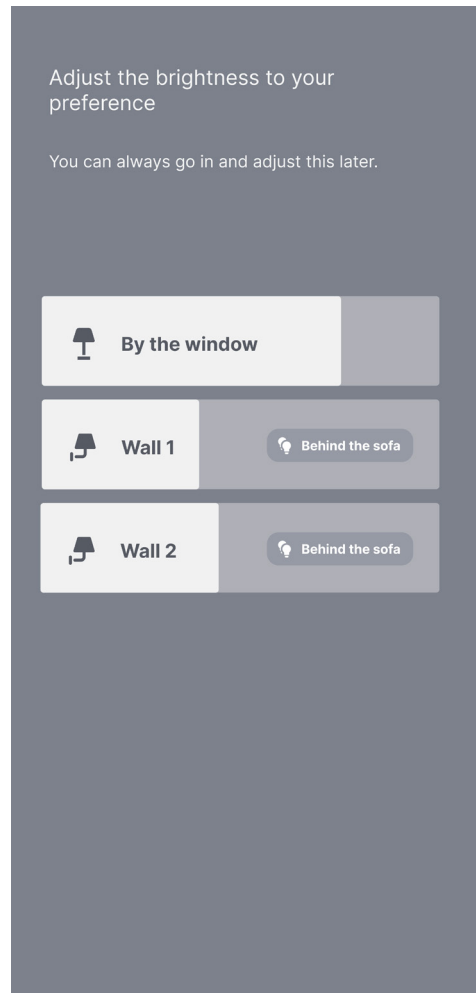
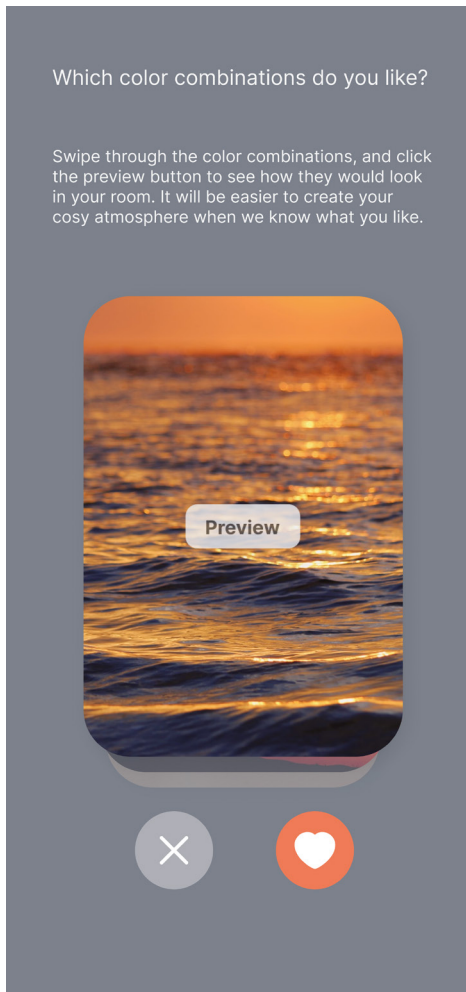
The sketches were not finished and were made to facilitate discussion with users. The crystal ball is not an isolated entity, but rather a part of people’s existing smart home setup, thus, users’ light sources will already be available.

We suggest a setup that allows users to pick the light sources to be used for the cozy light atmosphere, utilizing their knowledge and preference of the lamps in their homes.



We also suggest two ways of addressing brightness, firstly by ranking the lights based on their degree of light contribution to the room. In this way, one can balance the lighting by keeping a more neutral color in important light sources and adding more color to the smaller ones.

Secondly, by allowing the user to set the brightness to their preference. This may also be important in countries where the amount of daylight changes throughout the year.



As opposed to letting users pick their own color palettes, we suggest a setup that allows users to look through predefined palettes, suggestions will then be created according to their "profile". This caters for personal preferences, while leaving some unpredictability in the colors presented.

When do you want to be reminded to initiate a cozy atmosphere?

If you do not set any time slots the ball could start glowing at any time during the day.

Morning

07:30

to

09:00

Afternoon

16:30

to

22:00

Add

Lastly, we want users to be able to define time slots for when the ball should start glowing. This still leaves some room for unexpectedness, while making sure that the suggestion will come at a time when it is welcome by the user.

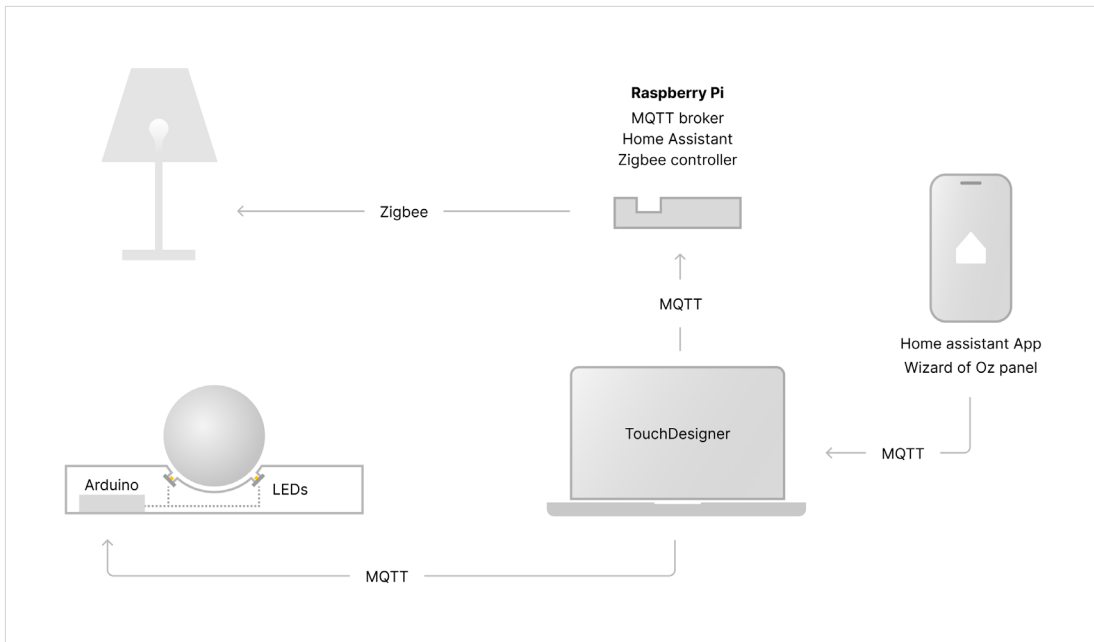


Figure 5.1: A technical overview of the final prototype.

## 5.5.2 Technical Details

A technical overview is shown in Figure 5.1. The prototype consists of five elements: smart home light bulbs, a Raspberry Pi 3 with a Zigbee controller running Home Assistant and an MQTT broker, a desktop computer running TouchDesigner, a crystal ball with a base housing six LEDs and a Wi-Fi-enabled Arduino Nano 33 IoT, and finally, a phone running the Home Assistant mobile app.

The Raspberry Pi, a small computer, is connected to a router via Ethernet. It runs Home Assistant as an operating system and hosts an MQTT server, known as a broker. The Pi is equipped with a Conbee II dongle, a small controller capable of communicating with smart devices such as smart bulbs over the Zigbee protocol. Home Assistant is responsible for the low-level logic of controlling the bulbs through the Conbee dongle. The main logic for coordinating which lamps to turn on and with which color is done in TouchDesigner.

When a light is to be changed, an MQTT signal is sent from TouchDesigner to Home Assistant, triggering an automation sequence in Home Assistant. The Arduino is also controlled through TouchDesigner, which sends an MQTT signal to the Arduino when it is to glow and with which colors. It also tells the Arduino to fade out when it is touched. The Wizard of Oz control is done through a panel in the Home Assistant mobile app. When a button in the Wizard of Oz panel is pressed, and MQTT signal is sent from Home Assistant to TouchDesigner.



Image 5.23: TouchDesigner tables storing the state of the lamps and the different color palettes.

## TouchDesigner

TouchDesigner is a visual development platform used primarily for creating interactive experiences and installations (TouchDesigner, 2023). Its versatility allows it to work with a variety of input devices, sensors, and data sources to create responsive content. Additionally, it can handle real-time graphics and video, making it a popular tool for creating media installations and live performances. TouchDesigner uses a node-based visual programming approach, where users create networks of nodes representing different project components. Such nodes can also be Python scripts, which makes it easy to combine the node-based logic with normal programming.

In this project, TouchDesigner serves as the prototype control hub, sending commands to both Home Assistant and the Arduino in the base of the crystal ball over MQTT. When a command is sent from the Wizard of Oz panel, for instance that the ball is touched, a series of events are triggered in TouchDesigner. First, an MQTT signal is sent to the crystal ball to make it start its fadeout animation, and signal is sent to Home Assistant to dim down



Image 5.24: The combination of noise channels in TouchDesigner

all the lights in the room. Then, a random lamp is selected, and is toned in with the color it is assigned in the selected color palette. The color palettes are stored as tables where each lamp is matched with an HSB value (hue, saturation and brightness) (Image 5.23). A timer is then set to add a delay before the next lamp is toned in. The timing is the same as in the Arduino code, so that one LED in the crystal ball will fade out as another lamp is toned in. This logic is done using Python scripts.

When all the lights are toned in, the organic brightness animation will start. This is made using time-animated Simplex noise curves, one for each per lamp (Image 5.24). Simplex noise is a type of gradient noise function, which outputs a smooth, continuous sequence of pseudo-random numbers (Simplex noise, 2023). With an uneven interval, a new brightness value, which is a sum of its original brightness and the Simplex noise value, is sent to a randomly selected lamp. Home Assistant handles the slow brightness transition for each lamp.

```

← Anim light 1
1 alias: Anim light 1
2 description: ""
3 trigger:
4   - platform: mqtt
5     topic: lights-anim/light1
6 condition: []
7 action:
8   - service: light.turn_on
9     data:
10      transition: "{{trigger.payload.split(' ')[3]}}"
11      hs_color:
12        - "{{trigger.payload.split(' ')[0]}}"
13        - "{{trigger.payload.split(' ')[1]}}"
14      brightness: "{{trigger.payload.split(' ')[2]}}"
15      target:
16        entity_id: light.light1
17 mode: single
18

```

Image 5.25: An example of an automation in Home Assistant. This one uses content from the MQTT message to set the light color of light 1.

**Home Assistant**

As mentioned, multiple predefined automation sequences are made in Home Assistant and get triggered by MQTT signals from TouchDesigner (Image 5.25). Some are fixed, such as the one dimming down all the lights. Others, such as the sequence toning in lights with a specified HSB color, rely on arguments passed with the MQTT message.

To make it easy to hide that the interaction mechanism is Wizard of Oz-based, we built a custom panel with trigger buttons in Home Assistant (Image 5.26).

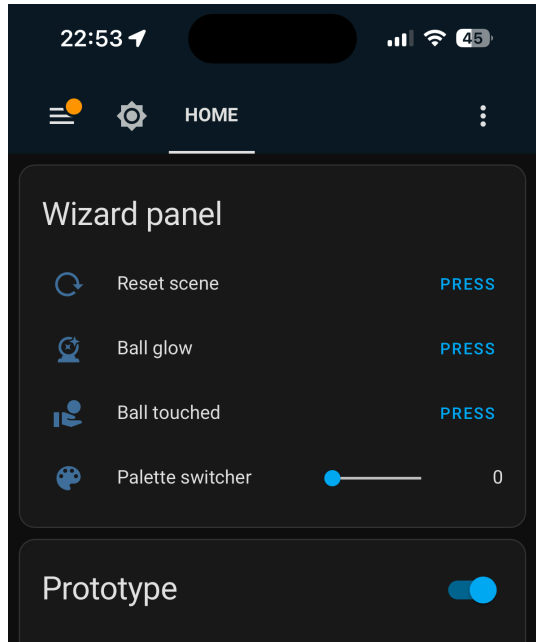


Image 5.26: The Wizard of Oz panel in the Home Assistant phone app.

**Arduino**

The Arduino code is relatively simple. The Arduino listens for MQTT messages with the “Arduino” topic, and the lights are animated by transitioning between colors in a color palette. Simplex noise is used to add some twinkling to the lights illuminating the glass ball. Both animation techniques are made easy by the utility functions in the FastLED Arduino library (FastLED, n.d).

The Arduino Nano 33 IoT has a built-in gyroscope, which we used to make it possible to interact with the crystal ball without relying on Wizard of Oz. When the crystal ball is tapped, it sends an MQTT signal to TouchDesigner, which starts the fading animation. This does however require the user to tap quite hard and does not match our desired interaction feel. We will therefore not use this in the user tests.



# 5.6 Feedback Sessions

The main goal of the feedback sessions was to gain insight into how people experience the aesthetics of the interaction and light animation. We also wanted to see how they felt about receiving a suggestion without the ability to adjust it. Additionally, we wanted to learn about their perceived value of the product over time, as well as how they want to set up the product to their preferences.

## 5.6.1 Setup

The interviews were set up similarly to the initial workshops and the previous feedback sessions, using the same lamps and furniture to create a smart home environment in the UX lab, we added an additional smart bulb, making it a total of five lamps. We placed the prototype on the table directly in front of the participants and made sure that they could clearly see all the lamps from where they were sitting, to ensure that they were able to fully observe the light animations.

As discussed in Chapter 5.1, we targeted participants living in more established homes for the user testing as adjusting the home atmosphere resonated the most strongly with this user group.

## 5.6.2 Procedure

Firstly we introduced our project, and asked some questions about the participants current living situations. Secondly, we introduced the prototype through a use scenario and asked the participants to think aloud when interacting with the prototype, and asked follow-up questions. Thirdly, we raised a discussion on how this product would work in the "real world", and got their feedback on the wireframe sketches. Lastly, we opened for a general discussion of the product such as its long-term value and form factor.



This is a an abbreviated version of the procedure. The full procedure of the feedback sessions can be found in Appendix H.

### 5.6.3 Results

#### Participants

We conducted seven feedback sessions with a total of nine participants. All participants were either living on their own or with their partner (one with kids).

Two of the tests were conducted with two participants (P1+P2 and P6+P7), while the rest were held with one participant each. Only one participant in this selection had education within design.

#### Feedback session 1

---

**P1**  
woman  
mid-30s  
lives with partner

**P2**  
man  
early 30s  
lives alone

#### Feedback session 2

---

**P3**  
woman  
early 30s  
lives with partner

#### Feedback session 3

---

**P4**  
woman  
late 20s  
lives with partner

#### Feedback session 4

---

**P5**  
woman  
late 20s  
lives with partner

#### Feedback session 5

---

**P6**  
woman (designer)  
mid-20s  
lives with P7 (partner)

**P7**  
man  
mid-20s  
lives with P6 (partner)

#### Feedback session 6

---


**P8**  
woman  
early 30s  
lives with partner

#### Feedback session 7

---

**P9**  
man  
mid-30s  
lives with partner and child

## Main findings

 This is an abbreviated version of the results. A more elaborate version can be found in Appendix I.

**All participants described the interaction as positive, using words such as calming, magical, and surprising to describe their experience.**

*"There was something a bit magical about actually having to touch it, it was very nice actually."* –P7

*"When it first gets dark, I think it's very atmospheric. Because I feel a kind of calm, right? So when it first gets dark, and then it gets a little lighter. It's a nice wave, at least if you want to get a sense of calm."* –P5

The theatrics of the animation, when the light leaves the crystal ball and spreads out in the room, were by four deemed to be appropriate in the home context. However, two questioned its relevance to their own life.

*"It depends on the social setting, it depends on what kind of mood you want to set. If, for example, I have my closest girlfriends over, it can be a nice thing. A little dramatic with more people, but clearly marks a subdued mood for everyone."* –P5

*"In my daily life, I don't think I would use it much. Mostly for the reminder to go to sleep."* –P4

**Some enjoyed the persisting light animation, some did not notice it, and some found it to be distracting.**

Out of the nine participants, three stated that they would prefer not to have the animation, or that the animation was too intense. Two did not notice it, and four participants wanted the animation.

*"It gives the feeling of being outside since there is a bit of changing light, I thought it was a bit cozy."* –P2

*"I didn't notice it"* –P6. *"Me neither"* –P7

*"It's a little interesting, but I was having a conversation it might be a little distracting."* –P4

**All participants perceived receiving suggestions from the crystal ball favorably, as long as they do not appear too frequently.**

*"Yes, [the suggestions] are a kind of reminder. I don't think of doing it myself, so having a reminder is nice. If it just stood there as a switch without lighting up, it would be just as difficult to remember to press it [...] Sometimes [when the crystal ball starts to glow] I think it would create a feeling of "now we have to hurry up to get ready for our evening quality time"* –P1

*"It can be nice. On the smartphone, it prompts us with messages that require more involvement than just tapping it. It's nice that it is a simple interaction and that it's very subtle. A one-time suggestion seems like a nice idea."* –P8

**Five participants expressed concern that some of the initial magic of the interaction would fade away. However, they still appreciated other aspects such as marking a shift in the mood and controlling all their light sources in a less digital fashion.**

Two participants found value in the interaction itself and the magical feeling that they associated with it. Five participants, including these two, were hesitant as to whether the awe or magic of the initial interaction would last over time.

*"If you allow yourself to be amazed by the magical feeling of 'today it was a bit like this instead of how it was yesterday,' then I think it will give you something."* –P1

*"Magic has a surprise element, at one point you wouldn't be surprised."* –P3

*"[The metaphor of magic] is not that important to me, for me it's that it creates an ambiance that is the most important actually. It has a bit of drama to it, so whether you call it magic or not doesn't mean that much to me."* –P5

Five participants noted that the larger idea behind the ritual carries enduring value because it helps mark a shift in mood and creates an ambiance for transitioning to a different activity. The participants also implied that they would use the ritual more frequently if they could integrate it into their daily lives or if the light it provided was desirable in and of itself.

*"It has value as a part of the routine. We are a family that follows routine a lot, and if there is one more thing to do, that helps us separate different activities, that is very welcome. To show that some things end and a different thing has started, it's really the flow of our actions."* –P9

*"The moment it gets dark and then the lights come on, it will continue to be a special moment, which I think remains magical and helps create an ambiance, because it's a bit dramatic and distinct."* –P5

Three participants appreciated that this method of controlling their lights feels less digital, and will retain its value with prolonged use.

*"It is a bit nicer than apps because it seems less technological. At the end of the day, I want to put my phone away."* –P8

### Magic and rituals is associated with families that have children.

Three participants believed the product would appeal to children, with one participant arguing that for them, the sense of magic will not fade as quickly. Furthermore, two argued that establishing routines is particularly important for younger children, where this product could be helpful.

*"Maybe others find [the magic] more interesting. For example, in a home with young kids, it can be very exciting. Making routines significant is so important in a life with small children."* –P5

*"[I see value in it] as part of routines. The rituals and the value of the rituals, you can't take it out of the context. Currently, our use context is training*

*the toddler to have better routines and to have better sets of activities. A family that doesn't have [kids] might see the value a bit differently, or not at all."* –P9

### Most participants were content with expressing their preferences during the setup

Seven participants expressed positive feelings about not being able to adjust the room lighting, two of these stated that it was a relief to not have to make decisions about adjusting the lights.

*"If it is supposed to be in the spirit of magic, I associate coziness and relaxation with the part of making decisions being over for the day. You are at work and have to decide, what to have for dinner, who will drive this weekend... When you relax, you should not have to decide if you should have purple or pink light, it becomes another thing you have to consider. It is in line with the idea of coziness."* –P1

Three also stated that receiving curated suggestions is more engaging than traditional smart home technology with multiple parameters: suggesting that having your lights set for you is part of the purpose of this product's existence.

*"Those who like to choose everything are not a good fit for this product anyways, they can have Philips Hue. But it's nice to get [colors] that go well together, that give a coherence that you may not have come up with yourself. Like coming to a restaurant where they only have a few good options."* –P6

Of the seven who were positive towards the suggestion, five were generally positive but wanted to make minor adjustments.

*"I am not very techy. I would like [just accepting something] as long as there are certain things I could choose; color, intensity, spectrum in color temperature, how long they should stay."* –P3

The last two participants experienced the preset suggestion as inconvenient and expressed a desire to adjust the light to themselves.

*"Inconvenient, I prefer tweaking it to how I want it. I wish it had more features."* –P4

*"I think I would prefer to be able to customize the light."* –P8

When we introduced the option of expressing their preferences during the setup, only the two participants who originally wanted to make adjustments preferred to set the light themselves, while the remaining seven were happy with only doing it during the setup. The seven also preferred swiping through a preset of light colors to give the system an idea of their preferences over picking the colors themselves.

*"I think [regular smart home apps] have a hundred more choices than I need or want. So that pre-curation works for me, at least."* –P7

*"Telling the system once is fine."* –P9

**People have individual definitions of what makes light "cozy," but generally, they tend to prefer warmer, dimmed light. To communicate their preferences, most prefer to choose between presets instead of manually selecting light colors.**

*"I like orange-like lights that feel warmer."* –P4

*"The typical thing is a bit dimmer light, it should be relaxing for the eyes, not so hard, strong, and glaring light. I think lighting candles, turning off the ceiling lamp, and just having smaller lamps around the room."* –P1

**Seven participants stated that they appreciated the product's material palette and overall design. A few expressed opinions regarding its dimensions and proportions.**

Five participants appreciated us using the crystal ball as a metaphor.

*"I like that it is a ball, and has the reference to a crystal ball, it's a magical thing."* –P8

*"Technology, but more mindfulness. Remember the MacOS version where the color of the sky in the desktop background changed according to the time of day? It was so nice. It kinda reminds me of that."* –P3

*"It falls somewhere between tech and magic; it's a smart home gadget, but it's cooler than other smart home gadgets. It stands out and does something more."* –P5

Among the nine participants, three preferred a larger ball, while another three favored a smaller base. The motivations behind these size preferences were not only based on aesthetic considerations but also related to space constraints and the desire to strengthen the magical metaphor.

*"The ball should be bigger because of its proportions compared to the base. [It would be] more aesthetically pleasing."* –P3

*"Because you are talking magic I would have put a bigger globe there. But I grew up with Harry Potter... It's for the fun of it!"* –P9

**All participants were open to the ball glowing at a random time, but wanted to define a time slot for when it could happen. Two also emphasized the importance of setting a different time for the weekends.**

*"I would appreciate it if there was an app where I could set it up. For example, from 6–7 pm. Then I'm usually on my way down from hanging clothes, etc. Enter the time and then it chooses within that time frame, and then I can go and change it."* –P1

*"Personally, based on how my day usually goes, I would not mind it being a ritualistic-same time-experience, but there are obviously different days; weekends are slightly different. Maybe my TV time could be a time slot where I know [it could start glowing]."* –P3

### 5.6.4 Limitations and Considerations

As the digital setup interface was not made functional, the prototype was limited in its customization opportunities. Thus, the inability to adjust the intensity and color of the lights and the organic animation made those who appreciated the colors we presented in the test react more favorably to the concept than those with different preferences. This inconsistency might have been mitigated with a more sophisticated prototype or a test setup where participants could provide some cues about their preferences before trying the prototype.

Moreover, there is a clear limitation to the amount of insight that can be generated in a feedback session conducted in a lab environment when attempting to validate how a product would integrate into someone's daily life. Although our primary objective was to verify the quality of the interaction and people's initial attitudes, the natural next step, if time permitted, would be to make the prototype self-sufficient and conduct in-context long-term testing. This would enable the evaluation of user satisfaction with the product as it becomes part of their daily routine and assess the product's potential to establish family rituals. We will come back to family rituals later in the discussion.

### 5.6.5 Discussion

#### **Metaphor quality**

Both the choice and mapping of the crystal ball metaphor seemed to work well. The participants did not have trouble discerning the metaphor source, and appreciated the mapping onto a more stylized, modern design object. As with most aesthetic decisions in design, personal preferences will always be present, such as the participant who would have appreciated a more literal metaphor mapping due to a personal fascination for magic.

#### **Product setup: Keeping the magical serendipity while accommodating different interiors and preferences.**

Our lessons learned about suggestions, tweaking and control from the explorations of autonomy seem to have helped us find a nice balance between individual configuration, curation and unpredictability. As seen in the tests, a cozy atmosphere was mainly associated with warm, dim lights. People's tendency to prefer a "safe" light setup limits the potential for varying the colors that are suggested each time. While being more experimental with different colors for smaller light sources might work well, this would only work in rooms with a high number of light sources. If this product was to be developed further, learning more about the range of colors people might appreciate is necessary.

#### **The crystal ball's ritualizing potential**

Although the light animation and physical prototype were appreciated for their aesthetic qualities, their lack of clear functional value means that we need to look elsewhere to evaluate the crystal ball's potential for serving a purpose in the home. The point of Rasmussen (2013) and de Jongh Hepworth (2007) of magical experiences fading as they become habitual were mirrored in the workshops. Its value, therefore, in addition to facilitating a pleasurable light atmosphere, we believe lies in its potential to facilitate a new family ritual.

The need for clearly marked transitions between activities in families with children was pointed out by two participants. This aligns with literature on the subject: Wolin and Bennett (1984) define family rituals as symbolic communication that brings satisfaction through repetition over time and family routines and rituals' important role in child development is highlighted as they provide structure, opportunities for identity building, and socializing within their cultural context (Spagnola & Fiese, 2007; Viere 2001). Thus, if the crystal ball could help build everyday rituals in families with children, that could be meaningful.

While difficult to assess without long-term testing, the prototype aligns well with Rappaport's (1971) components of a ritual, as summarized by Viere (2001). Each component lends itself to a distinct aspect of the crystal ball interaction:

1. *Repetition*: Each interaction with the crystal ball follows a similar process, leading to a slightly varied outcome each time. The product is designed for providing a recurring interaction and experience.
2. *Acting*: The engagement with the crystal ball transcends mere thought and expression, requiring a physical action.
3. *Special behavior or stylization*: The interaction with the crystal ball creates a unique experience set apart from common, everyday activities.
4. *Order*: The interaction has a clear beginning (noticing the glowing orb) and an end (all lights toning in), providing a contained space for the ritual.
5. *Evocative presentational style*: The light animations' theatrics are intended to mark a clear change of state and capture the attention, with effects distributed around the room.
6. *Collective dimension*: The crystal ball is intended to create a cozy atmosphere for the home's inhabitants, as conveyed during the user setup.

However, a lingering question remains: are rituals more potent when self-established, or can they be effectively introduced via a product designed with that intent? During our feedback sessions, participants engaged with the product directly. However, in a real-life scenario, the user would need to initiate the purchase. Does this act translate to creating a ritual, or should the object or action be more profoundly tied to personal memories or experiences?

Furthermore, if we decide to cater primarily to families, we must reevaluate the product's form factor. While the crystal ball's aesthetic and tactile appeal might be inviting, it is fragile and could potentially pose a hazard to children. Its cost may also be prohibitive. Therefore, the challenge would lie in striking a balance between preserving the product's symbolic and aesthetic values while ensuring its practicality and safety for all family members.

## 5.7 Reflections on Designing with Magic

**Magic as an aesthetic quality was a valuable guide in the design process, it ensured a connection between the “why” and the “how” and infused the final product with an element of surprise.**

Throughout the project, the aesthetic qualities of magic helped us remain focused on the emotional values for creating an ambiance in the home. The participant feedback tended to be convenience-related, so a supplementary guide in the design process was a valuable corrective. Staying true to the notion of magic resulted in a simpler product that focuses on experiences and emotional values rather than mere convenience.

The final product definitely holds a magical element of surprise and something unordinary as described by de Jongh Hepworth (2007), as well as the theatricals that can be seen in the Bang & Olufsen products that are infused with 'a touch of magic'. Although the awe of the first interaction might not last, the product also emphasizes a strong connection between the why and the how, as described by Lenz et al. (2013). The interaction to induce the ambient light has a close link to the experience that it will create, through the help of a clear metaphor.

**Common cultural expectations strengthened magic as a metaphor.**

Taking the source for the metaphor directly from magical artifacts clearly shaped the final product, and might have been the most valuable use of magic throughout the process. As previously mentioned, the metaphor seemed to work well and was clearly understood by the users. Common cultural knowledge of the crystal ball as a magical artifact might have contributed to making the metaphor easily conveyable.







# Conclusion: Evaluating the Magical Design Approach

As we conclude our thesis, we reflect back on how magic has served this project: on the significance of magic as a metaphor, as design inspiration, as an aesthetic quality, and as a design method in interaction design.

We also look at whether the magical lens helped in our original motivation of providing a different approach to smart homes – and whether doing the project has challenged our perspective on how the smart home design field can provide better user experiences.

### **Magic as a metaphor**

Physical artifacts that incorporate animation magic can be useful for dissecting and understanding complex concepts, such as agent autonomy, agency, and meaningful human control. They allow for physical constraints and glanceable insights into an agent's planned actions, which provide a concrete dimension to these typically abstract ideas. Nevertheless, despite this tangibility, animation magic doesn't necessarily alleviate the "creepiness" often associated with black-box intelligence. Moreover, employing the metaphor of magic for AI has its own pitfalls—it perpetuates the perception of AI as an uncontrolled force of nature, glossing over the fact that it is, at its core, a statistically-driven, error-prone technology, constructed and controlled by people.

Using metaphors in the creative process can be helpful for envisioning new products and interactions, and magical objects have proven to be a lucrative metaphor category. In our last design exploration, we used this metaphor to search for initial concepts. Striving to preserve the notion of the crystal ball also helped guide our idea refinement. Additionally, people's familiarity with magical objects made the metaphor easy to convey.

### **Magic as a design method**

Starting out, magic was leveraged for its potential to spark creativity during ideation workshops. However, we found that magic might be a better catalyst for creativity in completely open tasks than for those restricted to controlling light and sound, as users' focus shifted toward how things are currently operated.

More successful, however, was magic as a backdrop for bringing forward people's common imaginaries of what is magical. This included automation (a house that can "magically" sense how users want their lights), rituals (emotionally motivated action as opposed to mere convenience), and unpredictability and variation (the notion of objects living a life of their own). These are all concepts that can be found in magical stories and magical laws of causality. They hold aesthetic properties that influenced our process and the end result, and might not have emerged if magic was not leveraged.

### **Magic as inspiration for new design directions**

Our primary intention in this project was to use magic as an inspiration for new design directions. However, we found that magic, while inspiring, can sometimes lead ideas to be somewhat detached from reality. This was particularly noticeable in our exploration of automation, where our enthusiasm for a novel principle caused us to bite over more than we could chew, as the complexity of the problem got in the way of meaningful insights.

It is challenging to base new ideas solely on magic and to differentiate them from our current ways of operating technology. However, our commitment to magic from the onset led us to a simpler product that emphasized experiential and emotional values rather than complex functionality or limitless customization. The deviation from full freedom of choice stands in contrast to the modus operandi of the current smart home market, suggesting that the use of magic might expand the scope of interactions with technology.

### **Magic as a feeling and aesthetic quality**

Even though we initially didn't intend to create an interaction with a "magical feeling", this unexpected outcome emerged through our user testing and was appreciated by participants. While the awe-inspiring aspect might not be a long-lasting value, it did provide an enchanting aesthetic that seems to have the potential to enhance the emotional atmosphere in the home, as did our choice of materials and the unpredictability and variation of light.

The theatricals of the last prototype were inspired by magical experiences, which contributed to its potential for ritualization. Rituals are central to many forms of magical beliefs, making them a fruitful source of inspiration for those who want to facilitate new rituals through design.

### **Did it work as a way to fulfill the goals of our initial motivation?**

We set out to challenge the status quo of the smart home, leveraging magic to free us from the principles dominating the smart home domain. Part of the project's motivation was to move away from screens and voice control. Although our solution cannot compete in terms of functionality, we believe that it offers advantages regarding the interaction experience and users' presence in the home context.

Firstly, it is less disruptive to the conversations as it only requires users' motor skills without demanding their cognitive attention. Additionally, it allows users to create ambient lighting without placing a screen between themselves and the world - by existing in the same physical space as us and the people we surround ourselves with, the interaction integrates with the emotional side of domestic life.

**In conclusion**, magic in design can be a transformative tool. It challenges the values from which we normally design, and serves as a guide to a different aesthetic approach. The feeling of magic may fade over time, but its influence on the design process and the final product remains significant.

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# Figures and Images

## Images

### Image 1.1

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Bang & Olufsen. (n.d.). Beovision Harmony [Product image] Bang & Olufsen. Retrieved May 12, 2023, from <https://www.bang-olufsen.com/en/ca/televisions/beovision-harmony>

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## Figures

### Figure 4.2

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# Appendix

# A: Major Smart Home Platforms

## Apple HomeKit

Apple's smart home platform, HomeKit, is integrated into Apple's ecosystem, meaning it works seamlessly with iPhones, iPads, and Macs. HomeKit's strength lies in its security and privacy features (Apple Inc., n.d.). It also supports the Matter protocol, a new open-source standard designed to unify smart home devices and increase their compatibility.

## Google Home

Google Home is Google's smart home ecosystem, and works seamlessly with Google's hardware like the Google Nest Hub and Google Nest Mini (Google Inc., n.d.). Google Assistant, their voice-controlled AI system, can be used to control the system. Google Home supports a wide range of third-party devices and the Matter protocol.

## Amazon Alexa

Amazon Alexa is well-known for its advanced voice recognition and control capabilities (Amazon Alexa, 2023). With a range of Echo devices, you can control your smart home devices, ask for the news, play music, and more. The platform supports a broad range of third-party devices, including those using the Matter protocol. Alexa's "skills" (akin to apps) can enhance the functionality of the platform (Amazon Inc., n.d.).

## IKEA Dirigera (previously Trådfri)

IKEA's smart home platform is more limited in terms of automation and control compared to the above platforms (Ricker, 2022). However, Ikea has a range of affordable smart home products, like bulbs, smart blinds, and air purifiers (IKEA, n.d.). The compatibility with Matter and integration with Apple HomeKit allow users to infuse the platform with more automation (as long as they have an Apple TV).

## Samsung SmartThings

SmartThings is a versatile platform that allows for complex automation routines. It's compatible with a wide variety of devices and brands, which makes it flexible for different smart home setups (Tuohy, 2023). With the launch of Matter, one of SmartThings' main selling points is that there no longer will be a need for SmartThings hubs, as they will be integrated into other Samsung products, such as their TVs (Samsung, n.d.).

## Phillips Hue

The Hue platform by Philips is specifically designed for smart lighting. It offers a variety of dynamic lighting options, such as color-changing bulbs and light strips. Hue lights can also sync with music, movies, and games for an immersive experience (Philips Hue, n.d.).

## Nest

Nest, now part of Google's hardware division, has its own distinct ecosystem, offering a range of smart home products. The Nest Learning Thermostat, one of its flagship devices, learns your schedule and preferences, adjusting the temperature to save energy when you're away (Google Nest, 2023). Nest also offers security cameras and video doorbells, providing comprehensive home security solutions. All Nest devices can be controlled remotely via a smartphone and integrate well with Google Home for voice controls and automation (Google Nest, 2023).

# B: Workshop Procedure

1. Warm-up exercise where participants take turns in suggesting alternative ways to use an object. Firstly a TV remote, without mentioning magic, followed by a round where we introduce a ring as magical.
2. Free exploration: Explore ways of interacting with light and sound using the objects in this room. (Wizard of Oz by controlling lights and sound from a phone simultaneously)
  - Interaction with one object. What are the possibilities for interaction with the object? Take one thing, how would you control different products with this object?
  - Organization/composition of different objects. Optional placement. How would you use the objects together and compose different objects to do different things?
  - Communication through objects. Imagine that the smart home has the ability to make adjustments on its own. How could these adjustments be expressed through objects?
3. Scenario-based interaction: Take turns imagining you are coming home from work, and want to create a cozy light environment, as well as turn on some music. How would you do this in the magical living room?
4. Follow-up questions
  - How did it feel to interact with objects when imagining that they were magical?
  - How was the experience of coming up with new interaction patterns? Was it difficult to avoid basing the interactions on patterns and metaphors from the technology you are used to?
  - Did you recognize any patterns in how you preferred to interact with the technology?
  - A lot of the interactions you came up with today were only performed a few times. Imagine controlling your smart home over time. What factors would be important for these interactions in your everyday life? (Ex. In social situations, when leaving the house in a hurry, etc.)
  - Do you have any routines that you do everyday to feel better or enjoy yourselves? For example in the morning, when you come home, or in the evening?

# C: Elaborate Workshop Findings

## **Futuristic ideas appeared during the warm-up when people were not restricted to operating technology such as light and sound.**

When asked to think of magical ways of using the ceramic torus, the participants came up with far-fetched and futuristic ideas related to time, place, and super-human abilities. Two participants rotated the torus to indicate that they were making time go faster or slower. Another looked through the hole of the torus and stated that they could look into the future. One imagined they could jump through the hole to teleport to a different location. All participants also mentioned acquiring some sort of super-human ability from the torus such as looking through walls, hearing people's thoughts, understanding every language, or having unlimited reach when holding it. When starting the main task, some participants stated that they found it hard to not be restricted by their knowledge of technology.

*"It was easier to think magically with the ring during the warm-up. You think too technologically when controlling light and sound." –P3*

*"It was difficult to think of things that are not physically possible today. It has to make some sort of sense that it happens. The logical sense takes over." –P8*

## **All participants instinctively went for gestures when interacting with the smart home, and related this to magic**

The participants gravitated towards using gestures such as pointing, moving their hands up and down, and snapping their fingers, to control lighting and audio. They related this mode of interaction to magic because it made them feel like they had magical abilities.

*"If I were a witch, I would just use my hands". –P6*

*"If an interaction was magical, it would be because I felt like I had magical powers in interaction with something. Snapping or clapping, for example. 'Wow, I can do this!' Then I would feel magical." –P10*

*"If I were a witch, the intention and control should come from me, not from something I have learned from an object." –P2*

One participant mentioned the convenience of being able to control things from anywhere, especially if the gestures can be a bit "fuzzy" – that way the interaction could be more subtle, and you wouldn't have to prepare a very precise command as you would when asking a voice assistant. However, another participant expressed concern about accidentally triggering actions when gesturing or moving around the home.

*"Nice that things respond a bit subtly to things that you do. Practically speaking, you can do it from where you sit, and you have a bit of slack, so you don't have to be as precise as you have to be with Siri, for example." –P3*

*"Gesturing could be nice when intentional. But it's annoying if I'm gesturing while speaking [and something gets triggered]." –P4*

## **Physical versus digital interfaces**

In all the workshops, the participants discussed advantages of digital and physical interaction modalities (smartphone apps and voice assistants as opposed to dedicated, physical interfaces), where the main divide was between convenience and pleasure/presence. Three participants argued for the value of digital modalities with their availability; with your phone or with a voice assistant you can control your home from anywhere, and allow for a great range of actions accessible from one place.



*"Voice control is smart because you can do something else or avoid getting up." –P10*

*"On the other hand, it can also be annoying to get up if you are very comfortable on the sofa." –P8*

*"Practical when I'm about to leave with dirty shoes and forgot to turn off the light. Or dim it when you're sitting comfortably on the couch. It's accessible from where I am." –P4*

Others did however dislike centralized digital interfaces, two were hesitant to spend even more time on their phone, one was discontent with the feeling of interacting with a voice assistant.

*"I don't want to pick up my phone unnecessarily, suddenly you end up in a loop." –P5*

*"I like the physical aspect and don't want even more things on my phone. [...]" –P7*

*"It's not very sexy to be shouting at Google." –P7*

The perceived advantages of physical interfaces were partly motivated by aesthetics. One participant argued that introducing materials such as wood and stone would provide an inspiring contrast to the "technological" look of most smart home devices.

*"I was inspired by nice materials. Many will appreciate getting that back again. That it doesn't look so technological." –P5*

Two mentioned feeling more present in the world when interacting with a physical object and feeling closer to the thing they want to control. One also pointed out that the tangible dimension makes it less scary and futuristic.

*"It also has value in relation to presence: you disappear a bit from the social setting if, for example, you have to queue songs, but then you come back when it's done." –P2*

*"I like the physical aspect and don't want even more things on my phone. There's something comforting about having something tangible, physical to push. Something tactile that makes you feel closer to what you're controlling. It's like feeling what's happening in the car when you use manual gears." –P7*

*"It becomes less technological and more magical. It brings it back to the real world. It is not necessarily connected. But it makes it less 'futuristically scary', which is what you want to work towards." –P10*

Two participants pointed to the perceived affordances connected to different shapes, and how they guide the interaction.

*"I Would like to do something that fits with the physical control of the object, for example pulling an imaginary string to control a lamp that has a string." –P1*

*"Objects have a shape and affordances that we are used to. We want it to fit with our movement." –P2*

Still, three participants were concerned about the practicality of such solutions; small objects might be lost, and there is a risk that a tangible interface might feel more like a gimmicky add-on than something that provides real value.

*"It's a risk that it becomes a gimmick that's cool only once. It has to work, otherwise, you feel foolish, like sitting there hitting the cylinder without anything happening." –P7*

*"There is a great risk of things being misplaced when dealing with small objects." –P2*

*"I think I would have lost these small objects. The idea of something larger, like a wooden block is nice." –P8*

Four participants highlighted the handiness of light switches, and one participant concluded that it would be nice to combine digital and physical interfaces.

*"Interesting and intriguing, but maybe it's just as good to use the light switch?" –P10*

*"It's good to have the light switch when you need it." –P2*

*"It feels good to press the light switch." –P7*

*"If you have your phone in another place, it's frustrating not being able to use the light switch." –P5*

*"It seems nice to have the combination of physical and digital." –P7*

### **Automation is appreciated, but people want to remain in control**

The participants discussed different aspects of automation in the smart home, such as giving up control, what actions should, and should not be automated, and the feeling of being monitored.

Some automation was appreciated, such as lights adapting to outside sensors or predetermined scenes being automatically triggered by entering a room, turning on the TV, or by the time of day. Three participants said they enjoy a cozy mood created by lights and music, but that they might forget to set it themselves, and would appreciate the smart home to be an initiator.

*"I like cozy lighting, but I either forget to turn on the light that creates a cozy mood or I'm too lazy to go and do it. I would appreciate if the smart home knew that 'at 4 pm, she likes this and that to happen'." –P10*

*"A good argument why is that it's like a mother who brings you fruit slices, even though you didn't know you wanted it. Good intentions, and coming to you when you don't think of it yourself." –P3*

*"It can be nice if you need help from your surroundings to feel better, that you can pick up an object that symbolizes your mood, and the surroundings do something to help." –P1*

Another two participants added that they would like to be surprised by small variations in their pre-defined scenes, to add some degree of unpredictability and animacy to the smart home.

*"The lights notice when you enter the room and adjust to a predetermined scene. I could appreciate a little variation every time I enter, like with the weather, for example, the lights could compensate for rain by making it extra cozy. It lives its own life." –P3*

*"I prefer that things could change and be in different places for different things to occur, a bit of unpredictability, where you don't know what will happen when adjusting something." –P1*

One participant resented automation because they fear that it will deprive them of performing actions that they enjoy doing, such as creating a cozy atmosphere in the room:

*"It's not the right thing for me. I get the sense that the goal is to make things more efficient and convenient. I'm old-fashioned when it comes to new things, what does it give me and what does it take? I appreciate things that slow down the pace, small pleasures I can do in my everyday life." –P9*

The other participant in the workshop had a different view:

*"I understand the idea of the ritual that puts you in the mood. But automation doesn't remove the coziness, only the time and effort leading up to it." –P10*

To which the first participant responded:

*"But to light the match, I love it! Then I can blow it out and get the smell of the match." –P9*

Another participant exemplified the difference between choosing to be immersed in a task or automating it.

*"Cooking is nice to do yourself. But it's convenient if the oven can just turn on."* –P4

Other examples of tasks that could be automated were saving power, heat control, and watering plants.

Three participants mentioned the need for being in control of your smart home, regardless of their views on automation. The participants suggested different ways of denying an automated action initiated by the smart home, or to temporarily disable the automation completely.

*"At least one thing needs to be stable and safe so you have some control over the lights, but something around it can also be changeable, as long as you have stable control."* –P1

*"I want to turn everything off by taking removing the marble from the ring. But then maybe I'll put it back if I think 'it's a bit nice after all'. If I could know for sure that if I do this [takes out the marble from the ring] then it would turn off, then I would have a bit more control."* –P9

*"You have to be able to maintain control over the actions yourself, with automation it becomes a robot movie-like feeling, but if you initiate the automatic action it can be nice."* –P6

Two participants stated that being the initiator of changes gave a sense of control, and appreciated a small action putting something into motion.

*"I want things to happen somewhat automatically, that it senses the goal of my action."* –P2

*"A small thing to initiate it helps."* –P8

A discussion emerged on whether or not we should have endless options for controlling our homes.

*"I don't want to have too many options, then I would just get stuck. Where do you want to be on the scale between simplicity and options?"* –P9

## **Separating practical tasks from emotionally motivated actions**

In all four workshops, the participants discussed the trade-off between convenience and rituals – emotionally motivated actions – for setting the home atmosphere. In most situations they preferred a simple and familiar way of controlling the light and sound, however, two participants suggested an added emotional value by introducing a tangible and aesthetic way of setting the mood of the room.

*"It is important to separate hygiene factors from having a ritual. For hygiene factors, I want to reach out and do designated gestures to turn it on and off. In a ritual, I want to make a bigger deal of it, like lighting a candle or putting on a record."* –P3

*"For everyday life, it is better that things are kept simple. But if I have guests over it could be interesting to have a ritual where I can magically evoke the right ambiance."* –P5

*"When it comes to mood factors (lighting and music), it would be cool to have something nice on the living room table that can control your whole home. A subtle action that controls light and sound a bit in the background, and then things just flow while playing board games."* –P5

*"I would prefer something that enhances the feeling of 'now I'm going to enjoy myself'. Something like candles or an LP record."* –P3

One of them pointed out the need to define the objective when creating new interactions for smart homes.

*"It depends on what your goal is; easier, seamless interaction, or emotional qualities and an increased value."* –P5

**A creepy sensation ensues when one cannot understand the reasoning behind automated actions, and some dislike the feeling of being monitored**

One participant expressed feeling uncomfortable with not being able to understand the “thoughts” behind the automated actions of the smart home.

*“How can we understand an intelligent object? The smarter it is, the less we understand how it works. There is a creepy sensation, how does it know how I am feeling?” –P1*

On being monitored, two participants responded that they don’t like the feeling of being observed, especially not if they are under constant monitoring. One participant suggested voluntary monitoring by picking up a sphere and keeping it in your palm.

*“I feel uncomfortable being monitored. It should preferably be something that is not done all the time, to ensure a feeling of autonomy.” –P7*

*“I do not want to feel monitored, like if I am talking about coffee and then suddenly the coffee is there” –P6*

*“Picking up a ball that measures blood pressure. When you squeeze it, things calm down a bit. It feels good to hold the ball.” –P7*

On the other hand, some suggestions made by the participants would require some degree of monitoring.

*“I might have liked it if [the smart home] knew my mood” –P8*

*“It could learn my routines” –P7*

With regards to information security, one participant said:

*“I don’t mind giving away information on how I like my lights, compared to other sensitive information” –P7.*

**Magic means breaking with the expected**

Three participants associated magic with something unusual, an exception from what is expected.

*“The magic is an exception from everyday life. When something becomes part of everyday life, it loses its magic.” –P9*

*“I kind of forgot about the magic and focused more on the concept of unexpectedness.” –P1*

*“The most magical thing would be if things could read our thoughts. That something unexpected happens, but it is also expected because it is decided by the one who does the magic.” –P3*

One also mentioned that this magic disappears once you get used to it, and it becomes a part of everyday life.

*“The automatic lights in our garage were magical the first time we saw them. But now we know how it works. And if you do something every day it’s not magical anymore.” –P9*

One participant also pointed out that the illusion of magic is easily broken if the interaction is not precise enough, it needs to work perfectly.

*“Gimmick that is only cool once. It needs to work or else you feel stupid, sitting there hitting the cylinder without anything happening.” –P7*

### **Human-smart home dialogue and negotiation**

In the workshops following the pilot, participants were encouraged to think of ways of physically conveying the status of the smart home; how the smart home interprets a situation, or what changes it is planning to make. One participant suggested a pillar of stacked disks, where the disks would slowly protrude from the pillar if the smart home were planning to change something. The user could then abort or revert these changes by pushing them back in. One of them suggested a composition with a stick placed on top of a cylinder. The stick would rotate based on which mode the smart home wants to trigger. Two participants emphasized the importance of being able to stop unwanted changes initiated by the smart home.

*“Interrupting unwanted changes should feel like removing the needle from a record player” –P10*

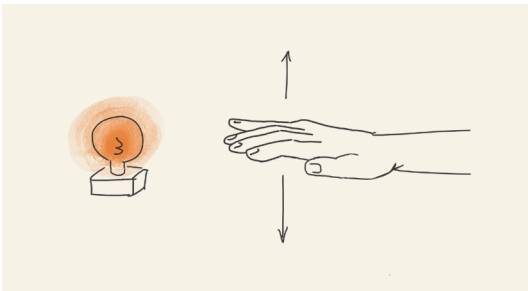
*“You see it starting to spin into a mode because you have to get up in the morning, but you can turn it a bit to get it back if you’re not ready to get up yet.” –P7*

# D: Interactions Proposed in the Workshops

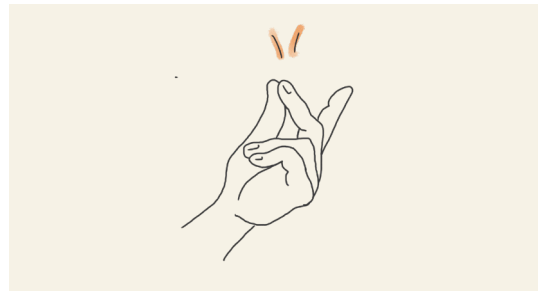
This is a brief overview of the interactions that emerged during the initial workshops. When interacting with the smart home, participants were allowed to openly explore whatever interactions occurred to them naturally. In addition, we encouraged them to interact with one object, then to organize and compose objects.

## Gestures

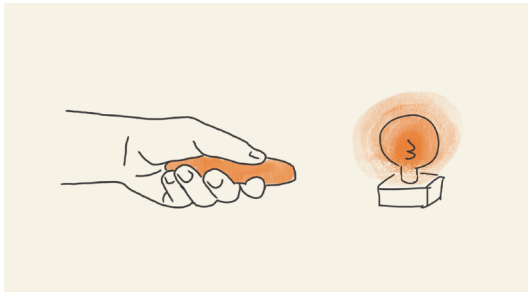
**Various gestures emerged in all workshops, without it being encouraged or mentioned to the participants.**



All participants reached out their arms towards the speaker or the light they wanted to control and most of them moved their hands vertically up and down to increase and decrease intensity.



Three participants snapped their fingers, some did it towards a specific lamp to toggle its light while others did it without direction to toggle all the lights simultaneously.



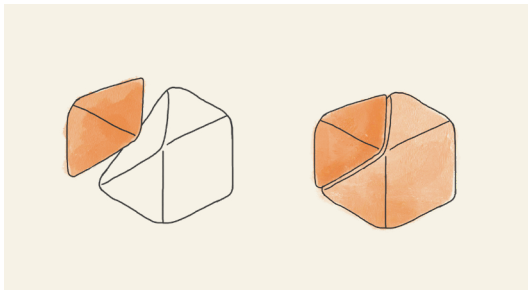
Four participants grabbed an object and pointed it toward the light or speaker that they wanted to control.



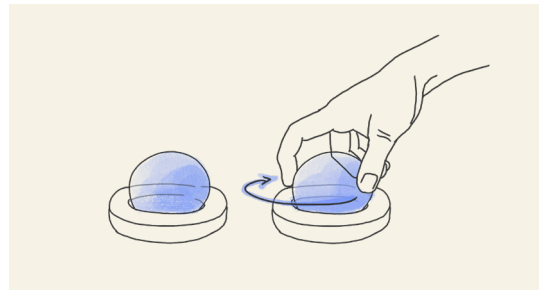
One participant preferred being close to the object they wanted to control and used a stick to either toggle the lamp by tapping it or to stroke it in a circular motion to adjust its brightness.

## Control by manipulating a single object

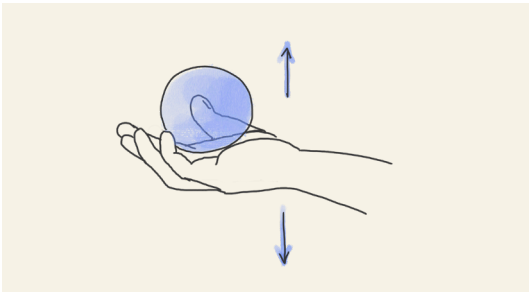
**Many participants instinctively manipulated the objects in the room to interact with the smart home. In the workshops following the pilot, we specifically encouraged them to do so.**



One added the missing corner of the cube, and “completed” it to turn on a lamp.



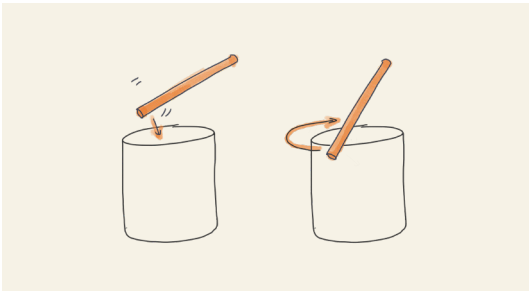
Two participants placed a glass marble in a torus and twisted the orb to adjust the intensity of light and sound.



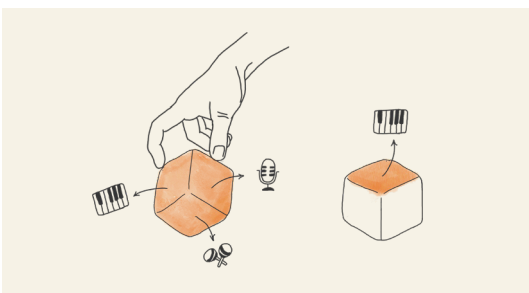
Two participants immediately pointed out the resemblance between the glass marble and the orb lamp placed in the room.



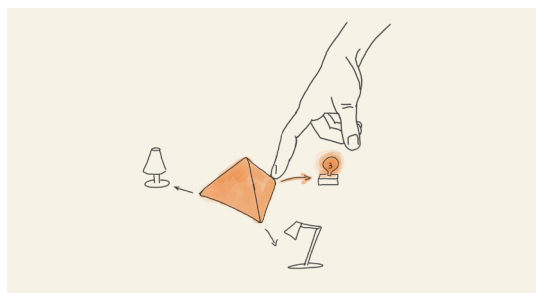
To dim the lights, one lifted the marble up and down, while both suggested that rotating it on the tabletop could dim the light.



Another one wanted the solid, plastic cylinder to represent the table lamp. They tapped and rotated the wooden stick on top of the cylinder to toggle and dim the lights.

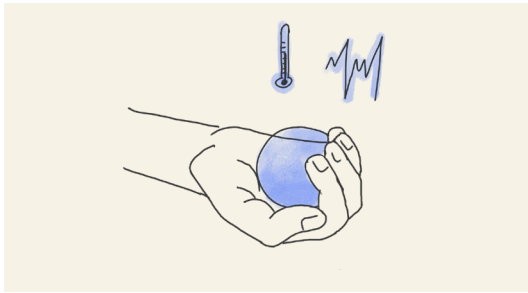


One participant connected each side of the cube to a music genre and tilted the cube to switch genres.



One participant oriented the triangle so that each point pointed towards a lamp, and toggled a light by pressing the corresponding point.



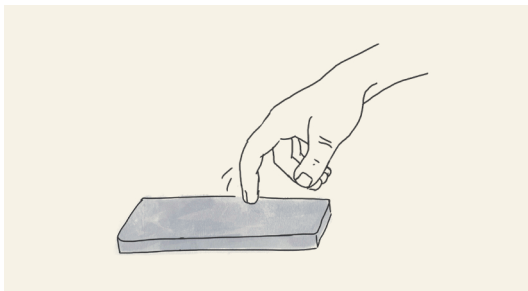


Two participants wanted to put an object in their hand and have it monitor their temperature and heartbeat.

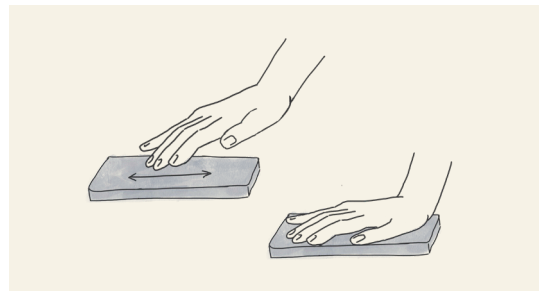


Another one wanted the mood of the room to become calm when squeezing the object.

**Several participants imagined that the objects in the room had touch-sensitive surfaces, and interacted with them correspondingly.**



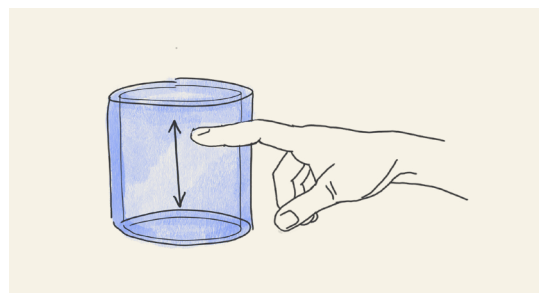
Two wanted to tap a wooden or stone slab to toggle lights.



One stroked the stone slab to dim lights, and one pushed their palm against it to create warm lights.

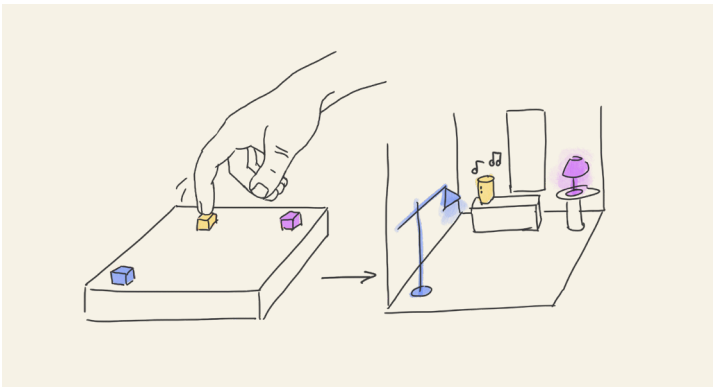


One stroked a ceramic torus clockwise to increase the lights, another one stroked a plastic cylinder to get the same effect.

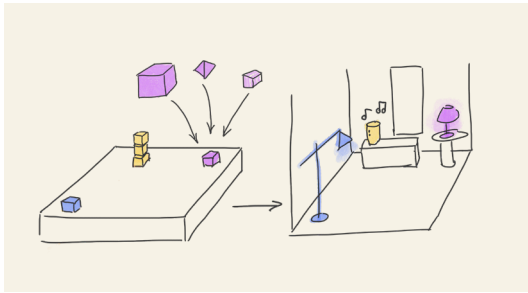


## Control by composing or organizing objects

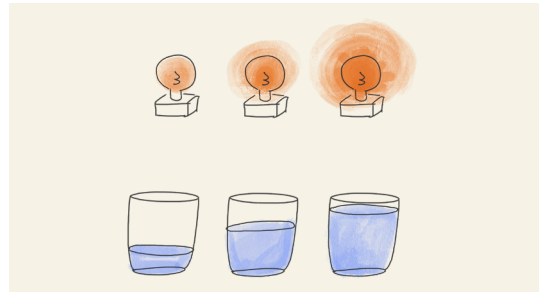
**Composing and organizing objects emerged naturally in some cases, and was also encouraged in the workshops following the pilot. There were two different mental models that dominated these interactions: the small object on a larger surface corresponds to each light or sound source in the room, or a small object on a larger surface corresponds to a predefined scene.**



Six participants toggled and adjusted light and sound by placing smaller objects on a larger surface, where a position on the surface corresponded to a lamp or a speaker in the room. One participant suggested pressing the small items to turn on and off sources of light.

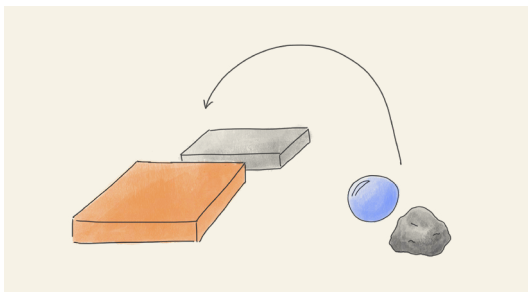


Other participants suggested that the intensity of light and sound could be adjusted by replacing a small object with another object of a different mass, shape, or material or by stacking similar objects in one spot. The small objects could also represent different music genres or the colors of light.



Following this principle, one participant chose to represent the room with liquid containers, and the amount of water poured into a container represented the volume or brightness of a lamp or speaker.

**Six participants initiated different scenes or moods by placing an object on a larger surface.**



Three of them stated that the material of the object was linked to a certain mood. Two participants connected different materials to different music genres, one associated wood with jazz, another one said that glass should give calm, spiritual music, they both agreed that stone represents rock music. One participant linked wood to warm and cozy lighting and stone to colder, more dimmed lighting due to how the materials feel to touch.



One participant suggested a stone slab that can recognize a cup of coffee and initiate a pre-set morning scene.

# E: Procedure Feedback Sessions (Chapter 4)

1. Warm-up discussion about smart homes, emotional qualities, and personal preferences when it comes to setting the atmosphere at home
2. Introduction to Smart Home Intelligence, Automation, and Agency. In the context of this test, we assume that the magical entity in the home has sufficient information about your movements, activities, routines, and other relevant factors. We also assume that it is capable of analyzing and synthesizing this information to develop insights about your preferred atmospheres in different situations and times.
3. We demonstrate the functional prototype (The weather vane). As it is changing state, we explain why a certain scene is set (e.g. you have come home from work and have made dinner; it's time for an evening atmosphere) to exemplify the potential reasoning of the system.
4. We will explain the logic of the second prototype, which differs from the first by incorporating physical barriers to adjust the level of agency, as well as a more fine-grained approach to the atmospheric parameters.
  - How do you feel about having to grant it permission to make certain changes?
  - How do you want to be made aware of suggestions?
  - Do you think you would be motivated and patient enough to train such an entity?
  - How do you imagine this would work in a household with multiple people with different preferences?
  - What is your tolerance for unpredictability in the changes of the intelligent agent?
  - As our scenes (focus, cozy, party, and morning), are just suggestions, what parameters do you think these sliders could/ should represent?

## Follow-up questions:

- How do you experience having an all-knowing entity making suggestions or decisions about how you should have it at home?
  - How does it feel to interrupt its decisions?
  - How is the trade-off between it being convenient when its prediction is right, and the annoyance when it's wrong?
  - What is your tolerance for suggestions that might be nudging you towards doing a specific activity?
  - Is there a value in having a physical object as opposed to an app?
5. To demonstrate the full range of agency, from complete autonomy to no agency, we will finally describe a hypothetical entity that is only allowed to make changes when you pick it up.
    - What degree of agency would you prefer?

# F: Elaborate Findings (Chapter 4)

## **There is skepticism towards automation where it is unclear why certain actions are triggered.**

This skepticism was expressed through doubts about the system's proper functioning. These doubts stem from either a lack of fixed routines or from living with multiple people who have different routines or preferences. Additionally, receiving indirect instructions through changes in the home can be perceived negatively when it comes from an autonomous agent.

*"How does it handle an unpredictable everyday life? My routines are exactly the same, but last week I was sick and didn't need an alarm clock. Then there should be a control system I have implemented. Should I design a routine or should the system follow me? How does it adapt to disruptions in routines?" –P4*

*"I want to understand what it wants to do. It's scary when you don't understand why it wants to do something, or what it's doing." –P9*

*"I would rather have control over it myself so that I can decide that it should make changes at different times of the day." –P10*

One participant was more positive towards these changes when the cause of changes in the home was clear, such as moving to a different activity.

*"If I didn't change anything, it would feel strange [for it to switch modes]. But if I get up and go to the kitchen and it changes, it would feel better." –P1*

Another concern is related to assurance: It is difficult to know what the intelligent object will do, and when it will be done. This was primarily expressed as concerns related to waking up: you need to know that they will wake up in time (or not be woken if they want to sleep in), and it

is challenging to know what decision the AI will make the following morning:

*"I would want to be able to decide the day before. For example, setting an alarm and then having it act accordingly. Give it some information." –P4*

*"I have to set an alarm as the last thing I do before going to bed. Otherwise, I'm afraid it won't go off." –P3*

## **The differences in the participants' living situations and their care for adjusting the home atmosphere clearly affected their responses and attitudes toward the prototypes and their perceived value.**

There is a clear difference in the perceived value of the solution when you compare the reactions from participants with different living conditions. The two first quotes below are from participants living in shared student flats, while the last two are from a married participant with their own home. Those living a busy student life and have flatmates with different preferences question how well a "magical" entity controlling their home atmosphere would work:

*"Life situation matters. We are not at home much, so it will take longer to learn our habits. I don't know how much patience I would have in an already busy everyday life to deal with yet another thing." –P10*

*"Someone I used to live with wanted it to be dark all the time. I wanted it to be bright. That would have been difficult for this thing to understand." –P9*

The married participant, however, was more open to the idea, and connected the unpredictability of an autonomous agent to its potential to shake up the atmosphere in a family with kids:

*"From a family perspective, [unpredictability] could be very fun. It could change a bad mood into something fun, like if it suddenly changes to party mode. Then everyone's mood would improve." –P1*

*"Fun thing when you have visitors, it becomes a topic of conversation. The kids can come and adjust it themselves. Then he [their son] can also take part in deciding how we should have it at home." –P1*

*"This would make it easier for my partner to initiate a cozy atmosphere. I get the impression that my partner likes it, but doesn't think of it themselves." –P1*

*"We are a bit too fond of gadgets, but it could be fun. Actually, I want to take it home now." –P1*

The notion that people's living situations and their care for adjusting the home atmosphere affect the perceived value of the prototypes was backed up by another participant living with a close friend:

*"It's probably not the thing for collective housing, people who come and go a lot, with a tight economy. But for more established homes, it is more relevant." –P7*

Another emerging factor was the wide range of sensitivity to the home atmosphere and the attention to adjusting it with lights. This also affects the perceived value of the intelligent system:

*"The motivation depends on how much you would gain from it. If it's only about dimming the lights when watching a movie, it's limited. I just need light, it's a bit individual." –P6*

*"I'm not good at setting the mood, but I really appreciate it when people do it. For example, 'when you put on a movie, then I dim the lights'. I'm very positive about the atmosphere, but it's something I don't want to do myself." –P5*

*"I hate institutional lighting, instead of overhead lights, I use small light sources and dim yellow lighting. We've hung a piece of paper in front of the switch for the overhead light. I also love candles." –P8*

### **People's openness to automation and suggestions from an autonomous agent, and how they perceive nudges, is determined by a complex set of factors related to context, personal preferences, and mood.**

When deciding whether they want the intelligent agent to follow their routines, or make suggestions, people consider their current situation, personal factors, and the probability and impact of errors. The same factors also affect whether individuals want the smart home to act autonomously or be limited to making suggestions only.

Their current context may include the time of day, or day of the week, the social context (home alone, having dinner guests, a party), and their current activity.

*"[My tolerance for unexpected changes] depends on my mode or mood. If I am in the middle of breakfast and it suddenly shifts to focus mode, I would just get annoyed. Or if you are in the zone and it suddenly becomes a party. But if it's 10 o'clock and I'm not working yet, it's okay if it turns on. Or if it's time to relax at 7 pm [if you've been working all day]. It depends on the mood." –P8*

*"Is it okay to lock this [parameter] out as well? To make sure that nothing weird will happen when I have people visiting." –P9*

Their openness to suggestions and automation varies over time because people are more routine-bound on certain days and during different times of the day.

*"I would like to have some degree of control. It's okay that it's smart and makes changes, but only for the things that I told it to pay attention to. For example, for our Friday habits, it's okay because we are always doing [the same thing]." –P9*

*"Everything in the morning [can happen by itself]" –P5*

More personal factors also came into play, such as their current mood or openness to "creative" suggestions.

*"It's great that it asks for permission, considering that you need to be in the right mood. It's nice that I can block it until I'm ready for it." –P8*

*"It is more [relevant with surprising suggestions] in the evening. It could help me to enjoy myself. It's about the atmosphere." –P3*

One participant expressed a need for a correlation between their current openness to changes and the frequency of changes.

*"There is a difference between it following me and me following it. I don't want to be controlled by it, it should adjust to what I am doing. It depends on how often it makes suggestions, if it's rare it can be fun, but as a habit, it should do what I prefer doing." –P9*

Two participants suggested a parameter to control the agent's degree of freedom.

*"I suggest one [parameter] that controls how much freedom it has, that one parameter is the frequency of suggestions and [AI] training you want. If it is high we are open to training it. If it is low it follows the thing that it already has learned." –P2*

*"I want to limit it in terms of frequency. One parameter for frequency and one for intensity?" –P5*

Two participants also felt more comfortable with autonomous changes if they happen smoothly and gradually, as opposed to abrupt changes.

*"I think I would let it do it [autonomously] if there wasn't too much going on. If the changes happen too often, I would get annoyed by it. If I almost don't notice changes happening it would be better. For example, if it gets darker outside it gets lighter inside." –P9*

*"[light that is turned on or off] should be done so gradually that you don't think about it." –P2*

Another major factor is the probability and impact of errors caused by misinterpretations of the situation.

*"I think it would take me some time to realize that it was making the right changes. The first time it enters party mode, it would be very fun, but it becomes annoying when it happens at the wrong time. If it is smart enough to do it at the right time, it would be a good thing. But what if it tells me to study, and I don't want to?" –P9*

*"With lights, it doesn't matter that much if it makes mistakes, then it's easier to trust it. The less significance an error has, the easier it is." –P3*

Overall, people have a lower tolerance for automation when they believe the "magical" intelligence would be unable to interpret and predict the complexity of their lives, social dynamics, and minor nuances in moods and routines. Our participants reflected upon this complexity, and how it affects whether a nudge is experienced as "nagging" or a friendly push.

*"To match a mood or try to boost a mood, if one is happy the mood should not be brought down, but if one hasn't slept well and just wants a dark room it might be okay with a little push to get going. At the same time, it should be okay to have a bad day every now and then." –P8*

*"I would like it to suggest things, if it acts on what I already do, then I don't get much new. For example, suddenly sitting in the dark. [It can] fix the lighting for people who don't understand how to set the mood." –P10*

*"I used to live with someone who wanted it to be dark all the time. I wanted it to be bright. That would have been difficult for this thing to understand."*  
–P9

**Four participants preferred the simplicity of not having to make decisions or "deal" with things. Six wanted to make their own fine-grained adjustments and set boundaries for the intelligent agent.**

When comparing the two prototypes, four participants saw advantages of the first prototype that makes decisions for you; in a routine-bound and predictable lifestyle they prefer full automation, rather than having to accept a suggestion:

*"To a full extent, I would have wanted it to make adjustments [on its own], with me being able to choose what it controls. I could let it control the lights and sounds. But I wouldn't trust it enough to control other things."* –P3

*"Having to say yes or no to a suggestion every time seems a bit cumbersome. Then I could just turn on the light myself."* –P4

*"The second prototype seems cumbersome, there are several dimensions I have to deal with. The first prototype should just take care of all the dimensions. The simplicity of it, and that it does it on its own. In my mind, it works for me and not for itself, like hiring someone, they make mistakes in the beginning."* –P5

*"The question is really whether you want to say no before or after things have happened. [...] I actually think I would let it happen, and then just pause it if not."* –P7

One argued for full automation by stating that being able to correct the agent would give them sufficient control:

*"I would choose that things just happen. [...] I can trust that it makes a decision, and correct it afterward, as long as it's easy to correct."* –P5

Five participants preferred the second prototype, as they wanted to limit the agency of the "magical" agent and set rules for what it could do.

*"I am clearly at the mid-point on the range between full automation and doing it myself."* –P1

*"It's okay for it to take some initiative, but it should be possible to limit it."* –P2

*"Sometimes you're in the mood to let it control, but other times you don't want it to."* –P6

*"If it is smart, it should happen automatically, but I would like to control the amount that is applied."*  
–P8

*"I kind of want to be open to things happening automatically, but it would be more comfortable to control it myself. Maybe you become more open to it over time because you get so used to it? It's still fun that I don't completely decide what happens."*  
–P9

*"I like the second solution because it combines both. [...] The more comfortable you become with it, the more you get used to it and can remove the walls. Eventually, it becomes like the first prototype."* –P10

Three of them preferred the second prototype because they like constructing their own atmosphere, by tweaking different parameters, or – instead of simply switching between modes – being able to apply a specified amount of that mode (e.g. a slightly more cozy atmosphere).

*"It's fun to think of an equilibrium. And then there's a degree of partying, from calm parties to techno parties. Every [parameter] has its levels. A mode within a mode."* –P7



*"Although I may appreciate the different modes, I am a person who can have a thousand different modes, not necessarily five or ten, it varies completely from day to day. [...] If it is smart, it should happen automatically, but I would like to control the amount that is applied. When you can go from zero to a hundred on different parameters, you control a lot more. Then you have a hundred to the fifth options instead of just five." –P8*

*"One thing that I liked better about this [second prototype] is that you can control the degree of things." –P2*

### **Thoughts on Home Technology that Can Learn**

The motivation to teach the intelligent agent and the patience to let it learn are tightly coupled with its perceived value.

*"It depends on the usefulness I would get out of [teaching it]. I don't know if I think this is something I need in life, it would rather be annoying to have to teach it. It's very okay to be able to make these choices myself." –P4*

*"Imagine if it never dares to suggest anything again if I say no. I want it to keep trying." –P7*

Less agency might mean less annoyance, but the potential for overlooking a more subtle interface made people worry that it won't learn a lot:

*"It is easier to forget it [when the AI is prevented from acting on its own]  
[Reply from another participant] –You never let it get out to learn." –P6 & P5*

*"I'm thinking that with the walls I prevent it a bit from learning. If I take too much control, it won't learn by itself. It's easy to override it. You have to trust that it can try to figure out if you want something or not." –P9*

One participant proposed a passive learning mode, where the artifact will act as a one-way interface until it has been properly taught:

*"Maybe it wouldn't do anything while you're teaching it, but as it gets better, it starts doing things. So that you can see that it's getting smarter and smarter." –P7*

The complexity of co-living was mentioned by four participants – who does it mainly learn from, and whose data will dominate its knowledge?

*"The problem is that it learns from two different people. If there are multiple sensors, it can detect the number of people in the apartment or who is in the apartment – if both mobile phones are nearby, are both present?" –P8*

*"It's difficult since there are many of us living together, my mode for coziness is probably something different than your mode for coziness. What happens when we are both in the kitchen?" –P10*

*"A person I used to live with wanted it to be dark all the time. I wanted it to be bright. That would have been difficult for this thing to understand." –P9*

*"If it wants to throw a full party based on my roommate, but I'm tired. Who should it prioritize?" –P7*

Being part of its learning – teaching it – might make people feel more familiar with it, and thus less creeped out when it starts acting on its own accord:

*"It would be less scary if I could see it learning gradually, and if I somewhat understood what kind of information it has. Why it does what it does." –P9*

### **The perceived value of a tangible user interface**

One participant didn't want any physical cues that the smart home was making changes, other than the emerging changes in light and sound.

*"I don't know if I want to see it happen, I just want it to happen and then I will get in the right mood" –P3*

Five stated that they appreciated the simplicity and convenience of a physical object.

*"I like that it is something physical that doesn't look so technological."* –P1

*"Proximity to where things are happening"* –P2

One stated that even though one might expect less functionality from a TUI than from an app, the limited functionality is more adapted to a home context.

*"It's nice to have a physical interface because it's simple. In an app, there's so much you can do. But a simple interface that blends in with the home is much easier. In an app, I would expect to be able to do much more."* –P8

Another one said that the TUI made the notion of their home being controlled by an autonomous agent less creepy.

*"It becomes a little less scary because it's a physical and friendly thing, that you're not just typing things in."* –P9

One stated that tangibility could be beneficial as one would be more observant of the object, and said that it makes it easier to recreate a light setting that you like.

*"Seeing how it moves, if you like [the light settings] at that moment you can remember those settings. [There is] value in having it on display, you become aware of its presence. You make an effort to use it actively. I wouldn't have used my home office as much if it was in the attic."* –P8

Four participants suggested that a physical object would work best when supplemented with an app, the main argument being the convenience of not having to stand up and walk over to the object to make adjustments. Another argument was that there is more room for multiple parameters in an app, seeing that the TUI would not be cumbersome to use at a certain level of complexity.

*"On mobile devices, there is much more room for parameters. You would probably need both. However, a physical object becomes a part of the room and the house."* –P7

*"It's cool to have a physical interface, I'm a fan of having a control center for lights. But it's not always the patience to get up and cross the room is there."* –P8

*"If it had been an app, I can't be bothered if there are a thousand things you can adjust"* –P9

*"[I want it] physically and on the phone. If I am working and it turns on music and I don't want it, then it's a hassle to have to get up to turn it off."* –P10

# G: List of Magical Objects Generated with ChatGPT 4

## Prompt

"Provide an overview of magical objects and artifacts from cultural history and explain what they do and how they are used."

1. **Mjöl­nir** (Norse Mythology): Mjöl­nir is the mighty hammer of Thor, the Norse god of thunder. It is said to be capable of leveling mountains, controlling lightning, and always returning to Thor's hand after being thrown. Mjöl­nir played a central role in many of Thor's battles against the giants.
2. **Philosopher's Stone** (Alchemy and Western Mythology): The Philosopher's Stone is a legendary substance said to possess the power to transmute base metals into gold, grant eternal life, and produce the Elixir of Life. Alchemists throughout history have pursued the Philosopher's Stone, with some believing it to be a symbol of spiritual enlightenment rather than a physical object.
3. **The Holy Grail** (Christian Legend): The Holy Grail is a dish, plate, or cup that is said to have been used by Jesus at the Last Supper and is believed to possess miraculous powers. It is often associated with the quest for eternal life, as it is said to grant immortality and endless youth to those who find it.
4. **Ark of the Covenant** (Judaism and Christianity): The Ark of the Covenant is a gold-covered wooden chest that, according to the Bible, houses the stone tablets containing the Ten Commandments. The Ark is said to possess immense power and is associated with divine intervention in battles and other miraculous events.
5. **Pandora's Box** (Greek Mythology): Pandora's Box is actually a jar, which was given to Pandora, the first woman created by the gods. She was told not to open it, but curiosity got the better of her. When she opened the jar, all the evils of the world escaped, leaving only hope behind. The term "Pandora's Box" is now used to describe a situation that may appear small or harmless but has the potential to cause great harm or chaos if unleashed.
6. **Excalibur** (Arthurian Legend): Excalibur is the legendary sword of King Arthur, said to grant its wielder unrivaled power and invincibility in battle. The sword was given to Arthur by the Lady of the Lake and symbolized his divine right to rule Britain.
7. **Flying Carpets** (Middle Eastern Mythology): Flying carpets are a legendary mode of transportation in Middle Eastern folklore. They are said to be enchanted with the power of flight, allowing their users to travel vast distances at high speeds. The concept of flying carpets has appeared in various stories and legends, such as the tales of King Solomon and the famous One Thousand and One Nights.
8. **The Gjallarhorn** (Norse Mythology): The Gjallarhorn is a magical horn that belongs to the Norse god Heimdall, the watchman of the gods. It is said that when Heimdall blows the Gjallarhorn, the sound can be heard throughout all the nine worlds of Norse mythology. To interact with the Gjallarhorn, Heimdall would hold it in his hand and blow it with a specific hand movement. The horn is believed to have the power to awaken the gods from their sleep, as well as to signal the coming of Ragnarok, the end of the world in Norse mythology.
9. **Cornucopia** (Greek and Roman Mythology): Also known as the Horn of Plenty, the Cornucopia is a symbol of abundance and nourishment. It is a magical object that can produce an endless supply of food and drink. In

- Greek mythology, the Cornucopia was created when the infant Heracles accidentally broke off one of the horns of the goat Amalthea, which nursed him.
10. **The Wand** (Various Cultures and Mythologies): Wands are magical objects used by witches, wizards, and other practitioners of magic to channel and focus their powers. Wands have been a part of various mythologies and magical traditions, ranging from ancient Egyptian to contemporary pop culture.
  11. **The One Ring** (The Lord of the Rings Trilogy): The One Ring is a powerful artifact in J.R.R. Tolkien's Middle-earth universe. Created by the dark lord Sauron, the ring has the power to control the other Rings of Power and grant its wearer invisibility. To interact with the ring, the user must wear it on their finger. However, prolonged use of the ring corrupts and consumes the wearer, eventually turning them into a wraith-like creature under Sauron's control.
  12. **The Crystal Ball** (Various Cultures): Crystal balls have been used in various cultures as a tool for divination and fortune-telling. Scrying, or gazing into a crystal ball, is believed to help the user see visions of the past, present, or future.
  13. **TARDIS** (Doctor Who): TARDIS (Time and Relative Dimension in Space) is a time machine and spacecraft from the British science fiction television series Doctor Who. It is a living, sentient machine that can transport its occupants anywhere in time and space. The TARDIS is famously known for being "bigger on the inside," as its interior dimensions are much larger than its exterior suggests.
  14. **The Genie's Lamp** (Arabian Nights): The Genie's Lamp, most famously featured in the story of Aladdin, is a magical oil lamp that, when rubbed, releases a powerful genie. The genie grants the person who summons them three wishes, but the wishes come with limitations and the potential for unintended consequences.
  15. **The Magic Mirror** (Snow White and German Folklore): The Magic Mirror is a talking mirror that can answer questions, often with riddles or cryptic phrases. In the story of Snow White, the evil queen uses the mirror to confirm her status as the fairest in the land until Snow White surpasses her in beauty.
  16. **Seven-League Boots** (European Folklore): Seven-League Boots are magical boots that allow the wearer to cover vast distances with a single step. They appear in various European folktales, including French, English, and Scandinavian stories. The boots often grant the wearer the ability to travel swiftly and effortlessly, making them useful in quests and adventures.
  17. **The Monkey's Paw** (W. W. Jacobs' Short Story): The Monkey's Paw is a magical artifact from a short story by W. W. Jacobs. It is a mummified monkey's paw that grants its owner three wishes. However, each wish comes with a terrible price, as the story serves as a cautionary tale about the consequences of meddling with fate.
  18. **The Magic Porridge Pot** (German Folklore): The Magic Porridge Pot is a folktale about a pot that can produce an endless supply of porridge when the proper command is given. When the protagonist forgets the words to stop the pot, the porridge overflows and floods the town. The story teaches a lesson about the potential dangers of unchecked abundance and the importance of responsibility.
  19. **The Corn Dolly** (European Folklore): The Corn Dolly is a traditional harvest figure made from the last sheaf of corn or wheat from the harvest. It is believed to house the spirit of the harvest and ensure the fertility of the land for the following year. The Corn Dolly is a symbol of protection and prosperity and is often kept until the next harvest.
  20. **The Dreamcatcher** (Native American Ojibwe Culture): The Dreamcatcher is a handmade object consisting of a willow hoop, a woven net or web, and various sacred items such as feathers and beads. It is believed to filter out negative energies and bad dreams, allowing only positive dreams to pass through and reach the sleeper. The Dreamcatcher serves

- as a protective talisman and a symbol of spiritual connection.
21. **The Matryoshka Doll** (Russian Folklore): The Matryoshka Doll, also known as the Russian nesting doll, is a set of wooden dolls of decreasing size, placed one inside the other. The dolls are typically hand-painted with intricate designs and are considered a symbol of family, fertility, and the continuity of life. While not inherently magical, they hold cultural significance and have become a popular symbol of Russian folk art.
22. **The Hamsa** (Middle Eastern and North African Cultures): The Hamsa, also known as the Hand of Fatima or the Hand of Miriam is a protective amulet featuring an open hand with an eye in the center. It is found in various Middle Eastern and North African cultures, including Jewish, Muslim, and Christian traditions. The Hamsa is believed to ward off the evil eye and bring good fortune, health, and happiness to its owner. It is often used as a decorative element in jewelry, wall hangings, and other artwork.
23. **Bag of Holding** (Dungeons & Dragons and Fantasy Literature): The Bag of Holding is a magical item originating from the tabletop role-playing game Dungeons & Dragons, but it has also made its way into various fantasy literature and popular culture. It appears as a small pouch or bag but has the ability to hold much larger objects and weights than its size would suggest. The Bag of Holding is a handy tool for adventurers and travelers, allowing them to carry a vast amount of items without being encumbered.
24. **The Blarney Stone** (Irish Folklore): The Blarney Stone is a block of limestone built into the battlements of Blarney Castle in Ireland. According to legend, kissing the stone endows the kisser with the gift of eloquence and persuasiveness. While not an object that can be carried or used, the Blarney Stone has become a popular tourist attraction, and the phrase "to kiss the Blarney Stone" is often used to describe someone who has a way with words.
25. **The One Thousand and One Ropes** (Arabian Nights): In the classic tale of Arabian Nights, there is a magical object called the One Thousand and One Ropes. When a person ties a knot in one of these ropes, they can summon a powerful djinn (genie) who can alter their surroundings or grant their wishes. By interacting with the ropes, characters can transform their environment, create lavish palaces, or make entire cities disappear.
26. **The Chronosphere** (Alice Through the Looking Glass): In Lewis Carroll's *Alice Through the Looking Glass*, the Chronosphere is a magical device that allows the user to travel through time. By using the Chronosphere, Alice can change her surroundings by visiting different points in time, thus altering the environment and the events that transpire around her.

# H: Procedure Feedback Sessions (Chapter 5)

## 1. Introduction and some questions about the participant's current living situation:

- What is your current living situation?
- What is your relationship to smart homes, is it something you use yourself?
- What rituals do you have for setting a cozy mood at home?

## 2. Scenario and interaction: Introducing the prototype through a use scenario and asking the participants to think aloud when interacting with the prototype, and asking follow-up questions.

*"Imagine it is February and the days are shorter than they are now, and as you are on your way home from school/work, the sun is setting. You come home and start cooking immediately. As you finally sit down at the table to eat, you see out of the corner of your eye that the ball on the table has started to glow softly. [ball starts glowing] That is when you notice that it has become completely dark outside, and the only light on is the intense and cold overhead light. You go over and put your hand on the ball..."*  
[encourage the user to put their hand on the ball, they observe as the room gets dark and the lights animate in]

- How did this experience make you feel?
- What you see is what you get. How do you feel about just receiving a suggestion, and not being able to tweak the lights?
- How do you feel about the nudge/ reminder to change the lights?
- How do you experience the variation in light (light animation)?
- It is a bit "theatrical", how would that fit into everyday life?

## 3. Product setup:

- What is a cozy atmosphere? It will be individual what one thinks is cozy, for example, how much light one wants, or how much color one is open to.
- How should this be adapted to different homes? All homes are decorated and lit differently, for example, the lighting used can have a big impact on the mood.
- When should the ball start to glow? We have envisioned that this is something that happens in the evening, but different lives have different needs. What should determine when it lights up?

Show the product setup wireframes:

- How do you feel about this setup?
- How much freedom of choice do you want, and how much should be decided by someone else? (is it okay to swipe through suggestions, or do you want to pick the colors yourself?)
- Is there anything we haven't thought of that is important during the setup?

## 4. Other thoughts about the product:

- How do you feel about the form factor/ the looks of it?
- How do you envision using this over time? Why/why not? How would it need to change over time for you to continue using it?
- Could you see yourself having this product?

# I: Elaborate Findings (Chapter 5)

**All participants described the interaction as positive, using words such as calming, magical, and surprising to describe their experience.**

*"I'm the kind of person who thinks cozy light is nice, but I never actually make it cozy myself, but if it was like just [putting your hand on the orb] then it would definitely be nice." –P1*

*"I thought it was very cool" –P2*

*"[The interaction] makes sense when you connect it to magic, because I think I see magic as when you're in awe – it's like an out of body out of senses experience with the hand" –P3*

*"I like orangy lights that feels warmer." –P4*

*"When it first gets dark, I think it's very atmospheric. Because I feel a kind of calm, right? So when it first gets dark, and then it gets a little lighter. It's a nice wave, at least if you want to get a sense of calm." –P5*

*"It's cool that the home becomes alive, with character and personality. But it may be that it's cool the first time, and beyond that, you want it to be more functional, to fulfill a need." –P6*

*"There was something a bit magical about actually having to touch it, it was very nice actually." –P7*

*"It's fun doing it for the first time. It's nice playing around. The light it creates is really nice." –P8*

*"[the initial light animation] was a surprise, dimming the light and then everything going back slowly to be lightened up was not exactly a surprise but more of like "aha", a happy surprise [...] I'm not sure how much novelty has to do with it." –P9*

The theatrics of the animation, when the light leaves the crystal ball and spreads out in the room, were by four deemed appropriate in the home context.

*"I can imagine that in my own life, such a ritual would fit after coming home, cooking dinner, walking the dog, preparing, cleaning up, and sitting down. [...] It could fit in here. It sort of pops up – if it's about a ritual; it's not a ritual to turn on a light switch. To touch it, and then blink, blink, blink – and now we're there. I think it makes more sense because if it had just been to touch the ball and then it turns on, it would just be a glorified light switch. And do we need that?" –P1*

*"In social settings makes sense, I was more concerned about day to day, but I see it now." –P3*

*"It depends on the social setting, it depends on what kind of mood you want to set. If, for example, I have my closest girlfriends over, it can be a nice thing. A little dramatic with more people, but clearly marks a subdued mood for everyone." –P5*

*"It's cool that the home becomes alive, with character and personality. But it may be that it's cool the first time, and beyond that, you want it to be more functional, to fulfill a need. [At the same time], there are many things we have that are just nice, like a record player; it could be nice to get a reminder from it to remember to use it." –P6*

However, two questioned its relevance to their own life.

*"In my daily life, I don't think I would use it much. Mostly for the reminder to go to sleep." –P4*

*"More as something that is fun to try than something we would use in our everyday life." –P7*

**Participants had varying opinions regarding the persisting light animation. Some enjoyed it, some did not notice it, and some found it to be distracting.**

Out of the nine participants, three stated that they would prefer not to have the animation, or that the animation was too intense.

*"I might want a little movement, but not as much as it is now. I like that it simulates natural light, and natural light moves a little."* –P5

*"Right now I don't have strong feelings about it, maybe it would be different for an hour. I would rather have stable light."* –P8

*"Depends on context, what I am doing when the changes are happening. Let's say, if it goes really dim when I'm reading it's not going to please me."* –P9

Two did not notice it.

*"I didn't notice it."* –P6 *"Me neither."* –P7

Four participants wanted the animation.

*"I get associations with being outdoors, being in the sun, and that a cloud passes by. [It is] not so intense that it would have been bothersome, I think."* –P1

*"[The movement] Makes me feel not bored, my brain makes me wait for it. It is stimulating."* –P3

*"It gives the feeling of being outside since there is a bit of changing light, I thought it was a bit cozy."* –P2

*"Too dark for my eyesight. But if I don't want to do anything it's nice."* –P4

**All participants perceived receiving suggestions from the crystal ball favorably, as long as they do not appear too frequently.**

*"Yes, [the suggestions] are a kind of reminder. I don't think of doing setting the atmosphere myself, so having a reminder is nice. If it just stood there as a switch without lighting up, it would be just as difficult to remember to press it [...] Sometimes [when the crystal ball starts to glow] I think it would create a feeling of "now we have to hurry up to get ready for our evening quality time"* –P1

*"Yes, I think I would have accepted the suggestion"* –P2

*"Depends, how often? When google home suggests things I didn't ask for its a bit annoying. I could see it in the home setting. Bright light for cooking, I would not mind the dimmed light for watching TV."* –P3

*"[I would keep it] on the desk, it would be nice if it reminds me to go to bed when it's getting late. I am very forgetful to go to bed. If I start working it is hard for me to stop."* –P4

*"It would be nice, I like to create a cozy mood."* –P5

*"If it makes the right suggestion, then it's super nice."* –P6

*"We often get home late, then dinner, and then TV. Maybe by getting the suggestion, we can think of doing something other than watching TV. A nudge to use the home differently."* –P7

*"It can be nice. On the smartphone, it prompts us with messages that require more involvement than just tapping it. It's nice that it is a simple interaction and that it's very subtle. A one-time suggestion seems like a nice idea."* –P8

*"It's one way to control everything. Its definitely not nagging"* –P9



**Five participants expressed concern that some of the initial magic of the interaction would fade away. However, they still appreciated other aspects such as setting the mood, controlling all their light sources in a less digital manner, and that it could help establish routines in families with children.**

Two participants found value in the interaction itself and the magical feeling that they associated with it:

*"If you allow yourself to be amazed by the magical feeling of 'today it was a bit like this instead of how it was yesterday,' then I think it will give you something." –P1*

*"[The interaction] makes sense when you connect it to magic because I think I see magic as when you're in awe – it's like an out-of-body, out-of-senses experience starting with the hand" –P3*

Five participants, including the two who found value in the magic interaction, were hesitant as to whether the awe or magic of the initial interaction would last over time:

*"The mood that the light creates has to provide something for it to be something that you continue to use. The interaction itself cannot be the only thing that gives you something." –P1*

*"Magic has a surprise element, at one point you wouldn't be surprised." –P3*

*"[The metaphor of magic] is not that important to me, for me it's that it creates an ambiance that is the most important actually. It has a bit of drama to it, so whether you call it magic or not doesn't mean that much to me." –P5*

*"It has to be good beyond [being] fun the first time to continue using it." –P7*

*"I assume that it would lose some sort of magic over time, unless it keeps getting a surprise effect. It would still be something to show off to friends and family." –P8*

Five participants noted that the larger idea behind the ritual carries enduring value, which extends beyond the interaction itself. This is because it helps mark a shift in mood and creates an ambiance for transitioning to a different activity. They also said they would use the ritual more frequently if they could integrate it into their daily lives or if the light it provided was desirable in and of itself.

*"The mood that the light creates has to provide something for it to be something that you continue to use. The interaction itself cannot be the only thing that gives you something. But the result with the light must be what gives you something." –P1*

*"I really like the concept of magic and ritual. I think; keep that, let that be your unique selling point." –P3*

*"The moment it gets dark and then the lights come on, it will continue to be a special moment, which I think remains magical and helps create an ambiance, because it's a bit dramatic and distinct." –P5*

*"It has to be good beyond [being] fun the first time to continue using it." –P7*

*"It has value as a part of the routine. We are a family that follows routine a lot, and if there is one more thing to do, that helps us separate different activities, that is very welcome. To show that some things end and a different thing has started, it's really the flow of our actions." –P9*

Three participants believed the product would appeal to children, with one participant arguing that for them, the sense of magic will not fade as quickly. Furthermore, two argued that establishing routines is particularly important for younger children, where this product could be helpful.

*"Maybe others find [the magic] more interesting. For example, in a home with young kids, it can be very exciting. Making routines significant is so important in a life with small children." –P5*

*"Neat feature if you have children. It could have been a gimmicky thing that they would have appreciated." –P6*

*"[I see value in it] as part of routines. The rituals and the value of the rituals, you can't take it out of the context. Currently, our use context is training the toddler to have better routines and to have better sets of activities. A family that doesn't have [kids] might see the value a bit differently, or not at all." –P9*

Three participants appreciated that this method of controlling their lights feels less digital, and will retain its value with prolonged use.

*"Technology, but more mindfulness. Remember the MacOS version where the color of the sky in the desktop background changed according to the time of day? It was so nice. It kinda reminds me of that." –P3*

*"It is a bit nicer than apps because it seems less technological. At the end of the day, I want to put my phone away." –P8*

*"It falls somewhere between tech and magic; it's a smart home gadget, but it's cooler than other smart home gadgets. It stands out and does something more." –P5*

It was also pointed out by three participants that it is an easy and accessible way to control all the lights at once.

*"The ability to set a mood on everything would be great. Could dim down to evening or work lighting." –P7*

*"[Its] value over time is to fairly easily create a cozy light setting without turning on every light." –P8*

*"It's one way to control everything." –P9*

**Seven out of nine participants expressed positive feelings about not being able to adjust the room lighting. Of those, five were generally positive but wanted to make minor adjustments. When we introduced the option of expressing their preferences during the setup, only the two participants who originally wanted to make adjustments still preferred to set the light themselves.**

Seven participants appreciated the curated suggestions. Three of these stated that receiving curated suggestions is more engaging than traditional smart home technology with multiple parameters: suggesting that having your lights set for you is part of the purpose of this product's existence.

*"I like the idea of not being able to decide completely for myself, that you can be a little surprised. Because if you choose completely for yourself, some of the purpose is lost." –P2*

*"I don't like to have a lot of smart things in the home. And I don't want to have too many choices, I like recommendations." –P9*

*"Those who like to choose everything are not a good fit for this product anyways, they can have Philips Hue. But it's nice to get [colors] that go well together, that give a coherence that you may not have come up with yourself. Like coming to a restaurant where they only have a few good options." –P6*

Two of these stated that it was a relief to not have to make decisions about adjusting the lights.

*"If it is supposed to be in the spirit of magic, I associate coziness and relaxation with the part of making decisions being over for the day. You are at work and have to decide, what to have for dinner, who will drive this weekend... When you relax, you should not have to decide if you should have purple or pink light, it becomes another thing you have to consider. It is in line with the idea of coziness." –P1*

"We often listen to Discover Weekly (a playlist of personalized, curated music suggestions from Spotify), where you leave the mood and vibe up to a suggestion from your phone. It's nice if you're open to the idea of 'okay, now the lights can decide for themselves a little bit'." –P7

Of the seven who were positive towards the suggestion, five were generally positive but wanted to make minor adjustments.

"Adjust the movement of the light, maybe for the different lamps." –P5

"I am not very techy. I would like it as long as there are certain things I could choose; color, intensity, spectrum in color temperature, how long they should stay." –P3

"[It would have been nice] to be able to change it a bit according to what you want." –P6

"Colors are okay [to specify myself]. If the TikTok lights had come on, I would have been disturbed, while the warm [light] can be pleasant." –P7

"It could be nice if I could add my color preference." –P9

The last two participants did however experience the preset suggestion as inconvenient and expressed a desire to adjust the light to themselves.

"Inconvenient, I prefer tweaking it to how I want it. I wish it had more features." –P4

"I think I would prefer to be able to customize the light." –P8

When we introduced the option of expressing their preferences during the setup, only the two participants who originally wanted to make adjustments still preferred to set the light themselves, while the remaining seven were happy with only doing it during the setup.

"I imagine that I set it up the way I like it once, and then it becomes like that. I set the brightness of the lamps once, and don't necessarily have to go in every time, but can define it when setting up the system." –P1

"I think the same, that the app must be very simple for you to enter things, [such as] color of lights. But if the product is to have a purpose, it is okay not to decide everything." –P2

"It makes sense for the scope, it's not trying to do more than what it is." –P3

"If at some point I can set preferences for [light] movement, if those preferences are in place and it follows it, then I think I would like it." –P5

"Those who like to choose everything are not a good fit for this product anyways, they can have Philips Hue. But it's nice to get [colors] that go well together, that give a coherence that you may not have come up with yourself. Like coming to a restaurant where they only have a few good options." –P6

"I think [regular smart home apps] have a hundred more choices than I need or want. So that pre-curation works for me, at least." –P7

"Telling the system once is fine." –P9

**People have individual definitions of what makes light "cozy," but generally, they tend to prefer warmer, dimmed light. To communicate their preferences, most prefer to choose between presets instead of manually selecting light colors.**

"The typical thing is a bit dimmer light, it should be relaxing for the eyes, not so hard, strong, and glaring light. I think lighting candles, turning off the ceiling lamp, and just having smaller lamps around the room." –P1

"I'm not sure if it's a personal thing. But my father is an army officer, and in [my country's] army housing there is typically warmer color with yellow lights. He believed in not having one big light, but I light the room with these smaller things. So I think I might have a personal bias of the smaller lights and the warmness." –P3

"I like orangy lights that feel warmer." –P4

**Seven participants appreciated the product's material palette and overall design; however, a few expressed opinions regarding its dimensions and proportions.**

Generally, seven participants liked the overall design.

"[...] But it is very nice and you get the feeling of a crystal ball. It's nicer that it glows inside the ball rather than if it were a button." –P1

"I like the wood, maybe even darker and more brown." –P3

"I like things that are simple, there is something simple about a square and a sphere. It's a design that fits well in many homes, both simple IKEA decor and more modern homes." –P5

"Really nice, it could have fit on our shelf." –P6

"The wooden base fits very well with out taste. And I would actually like to just sit and hold that ball." –P7

"I personally like the wooden plate, it keeps it very simple." –P8

"The form factor is good" –P9

Five participants appreciated us using the crystal ball as a metaphor.

"The box could have been smaller. But it is very nice and you get the feeling of a crystal ball. It's nicer that it glows inside the ball rather than if it were a button." –P1

"The ball gives a magical feeling. I think it's fun, it's different from other things you have in the home." –P5

"It gets the best from boho magical orb, but put into a modern context." –P6

"Like that it is a ball, and has the reference to a crystal ball, it's a magical thing." –P8

"Because you are talking magic I would have put a bigger globe there. but I grew up with Harry Potter... It's for the fun of it!" –P9

Among the nine participants, three preferred a larger ball, while another three favored a smaller base. The motivations behind these size preferences were not only based on aesthetic considerations but also related to space constraints and the desire to strengthen the magical metaphor.

"I would have liked the ball to be a little bigger." –P2

"The ball should be bigger because of its proportions compared to the base. [It would be] more aesthetically pleasing." –P3

"Because you are talking magic I would have put a bigger globe there. but I grew up with Harry Potter... It's for the fun of it!" –P9

"The box could have been smaller. [...]" –P1

"The base is too big. It would be too big for a desk." –P4

"The wooden base could have been smaller." –P6

**All participants were open to the ball glowing at a random time, but wanted to define a time slot for when it could happen.**

*weekends are slightly different. Maybe my TV time could be a time slot where I know [it could start glowing].” –P3*

*“I would appreciate it if there was an app where I could set it up. For example, from 6-7 pm. Then I’m usually on my way down from hanging clothes, etc. Enter the time and then it chooses within that time frame, and then I can go and change it.” –P1*

*“For it to have a purpose, it is better not to decide everything, but to set some time frames.” –P2*

*“For the afternoon it depends on what mood I want to be, if I have to catch up on work this is not the mood I want. I think more towards the evening when I have to go to bed, it would be nice.” –P4*

*“I actually think it’s nice [that it happens within a time frame]. My days don’t look completely the same, so it’s nice to have that variation. In the summer, maybe you want to change the time frame.” –P5*

*“People might be open to something different in the morning than in the evening.” –P6*

*“I think [regular smart home apps] have a hundred more choices than I need or want. So that pre-curation works for me, at least.” –P7*

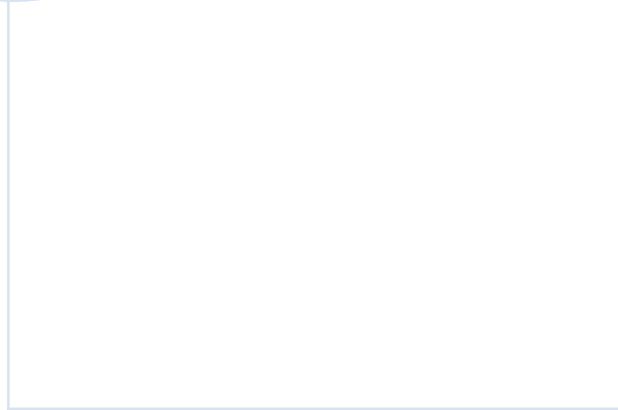
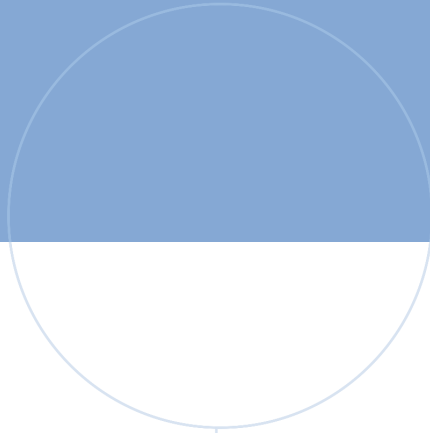
*“I think it can be fun to just wait for it and see when it comes up. But then you often want certain light for a certain time, when you are ready for it, how would that interfere with it?” –P8*

*“Want it to happen at random times, time wise I would not like to have a setup.” –P9*

Two also emphasized the importance of setting a different time for the weekends.

*“It must be different on weekends.” –P1*

*“Personally, based on how my day usually goes, I would not mind it being a ritualistic-same time-experience, but there are obviously different days;*



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