

Design of Feedback and Interface for a Digital Lock

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phoniro

ASSA ABLOY



Design of Feedback and Interface for a Digital Lock

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Abstract

This thesis was performed in collaboration with Phoniro AB, that develops digitally unlocked products that are mainly used in home care service. The purpose of the project was to develop one of their products through a user-centered design process. To determine which product had the greatest development potential, an evaluation of three products and the associated app was conducted. A custom heuristic evaluation form was created and used to evaluate the products and the app.

After the evaluation, Phoniro's medicine cabinet was chosen to be developed with the aim of improving the user experience. Some focus was also placed on the app as the user experience is strongly dependent on the interaction between the app and the medicine cabinet. Through interviews with the medicine cabinet's regular users, needs were identified, and personas created.

In the development of the medicine cabinet, great focus was put on the feedback during the unlocking process, since it had no feedback implemented. Different variants of light and audio feedback, as well as an integrated light were implemented based on suggestions from the interviews. A prototype of the app was created and the unlock page was re-designed. The prototypes were tested in three iterations with a total of 13 users, and they were updated between the test rounds according to the test persons' suggestions and results. After the third round of tests, a final proposition was created, both regarding the app's interface and the cabinet's implemented feedback. The proposition was evaluated through a final round of user tests with three users.

The results showed that implementation of both audio and light feedback was appreciated. Light feedback throughout the entire unlocking process was considered to be clearest. Yellow, flashing light was by far the most popular option for the loading process among the users, and blue for the connection process. Whether the users thought the blue light should light constantly or flash varied but the flashing light was preferred by 80 %.

Keywords: feedback, user experience, user interface, user-centered design, interaction design, digital lock, medicine cabinet, home care

Sammanfattning

Detta examensarbete har utförts i samarbete med Phoniro AB som utvecklar produkter med digital uppläsning och används främst inom hemtjänsten. Syftet med projektet var att utveckla en av deras produkter genom en användarcentrerad designprocess. För att avgöra vilken produkt som hade störst utvecklingspotential genomfördes en utvärdering av tre produkter samt den tillhörande appen. En anpassad heuristisk utvärderingsmall skapades och användes i utvärderingen av produkterna och appen.

Efter utvärderingen valdes Phoniros medicinskåp att utvecklas vidare med syftet att förbättra användarupplevelsen. Visst fokus lades även på appen då användarupplevelsen är starkt beroende av samspelet mellan appen och medicinskåpet. Genom intervjuer med medicinskåpets användare kartlades behov vilket gav underlag för att skapa personor.

I utvecklingen av medicinskåpet lades stort fokus på feedback under upplåsningssidan, eftersom det saknades. Olika varianter av ljud- och ljusfeedback, samt en integrerad lampa, implementerades efter förslag från intervjuerna. En prototyp av appen skapades och upplåsningssidan designades om. Dessa prototyper testades i tre iterationer med sammanlagt 13 användare och uppdaterades mellan de olika testomgångarna utefter testpersonernas resultat och önskemål. Efter de tre omgångarna med tester togs ett slutgiltigt förslag fram, både gällande appens gränssnitt och den implementerade feedbacken. Detta utvärderades genom en sista omgång användartester med tre användare.

Resultatet visade att implementering av både ljud- och ljusfeedback var uppskattad. Ljusfeedback under hela upplåsningssidan ansågs vara tydligast. Gult, blinkande ljus var överlägset mest omtyckt av användarna för den laddande processen och blått för uppkopplingsprocessen. Huruvida användarna tyckte det blå ljuset skulle lysa konstant eller blinka varierade men det blinkande ljuset föredrogs av 80 %.

Nyckelord: feedback, användarupplevelse, användargränssnitt, användarcentrerad design, interaktionsdesign, digitalt lås, medicinskåp, hemtjänst

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Lund, May 2021

Eleonor Hoffmann and Daniella Jonsson

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1 Introduction

This section presents the challenges with an aging population and a presentation of the company Phoniro AB. This is followed by the purpose of the thesis and definition of concepts.

1.1 Background

In recent years, the population in Sweden has grown rapidly. In 2028, the population consisting of people who are 80 years and older are estimated to increase with 50 percent, a growth of 255,000 persons. In addition to the fact that there are large birth cohorts that are in this age group, the increasing life expectancy also contributes to the number increasing [1].

In 2019, about 35 percent of women and 27 percent of men of the population 80 years or older have home care [2]. If the needs within the age group continue to be the same, care for the elderly faces major challenges [3]. These problems can be reduced by developing welfare technology that helps the care become more time efficient.

1.2 Phoniro AB

Phoniro is part of ASSA ABLOY Global Solutions and develops digital welfare technology for the growing senior population and other people who, for various reasons, need home care services. Their innovative products and solutions are used to maintain or increase security, activity, participation and independence in the care receiver's home.

The products that belong to Phoniro's solution for *Digital key management* are opened through an app on the staff's mobile phone. The solution increases staff efficiencies and workflow since the daily management of keys is a major, costly issue for home care services. A system with standard keys requires greater travel time and waiting for colleagues in order to obtain the right key. Keys can also be

lost, end up in the wrong hands and be duplicated. These problems are solved with digital key management [4].

Digital key management requires training, something that is not required with standard keys. The variation of knowledge within the field of technology is great among home care staff. The staff work mainly with people, not technology. As staff turnover is high and logistical challenges arise in gathering the entire staff for the training, intuitive design is significant.

1.3 Purpose

The goal of this master thesis consists of two parts. One is to make a thorough analysis of Phoniro's products that belong to the *Digital Key Management* for home care. The products will be evaluated from a user experience perspective. The second part is to choose the product with the greatest development potential and make changes to improve its user experience. The chosen product will be re-designed, and the development will follow a user-centered design process. The changes will then be evaluated to confirm that they have improved the user experience.

1.4 Definition of Concepts

In this report, the term “care receivers” refers to the receivers of home care, in whose homes the products are located. The “users” are the persons interacting with the products by locking/unlocking, changing the batteries etc. The “users” are mostly home care staff but, in some cases, the user is an installer.

The care receivers’ names, locks, personal identity number, addresses and telephone number used in this report are made up.

2 Theory and Methods

This section covers the theory and methods needed to understand the process of the thesis. It begins by explaining relevant design terms, followed by defining the guidelines in the Principles of Universal Design, Jakob Nielsen's Ten Usability Heuristics and Don Norman's Design Principles. Furthermore, the methods used in the design process are explained.

2.1 Design Terms

2.1.1 User-Centered Design

User-centered design (UCD) focuses on the real users and their goals. Users are studied and observed, while doing their normal tasks, and are involved throughout the design process to ensure that the development is relevant to their needs. User testing with prototypes is performed, the user's reaction and performance is observed and analyzed. When obstacles are identified, the design is improved, and further user testing is performed. This is referred to as an iterative design process. [5, p. 48]

2.1.2 User Experience and User Interface

User experience (UX) is about users' feelings for a product, system or service and how they use it. It includes their overall impression when they use, look at and hold the product. It is not possible to design a user experience but only to design features for it. Many aspects of the user experience can be considered, and of central importance are usability, functionality, aesthetics, content, emotional appeal, look and feel [5, pp. 13-15].

When designing for a user experience, it is important to identify the users' needs and design accordingly. In addition to meet the needs, simplicity is necessary for the users' enjoyment of the products. The user interface (UI) is an extremely important part of the design but must be distinguished from the UX [6]. UI refers to

the components of an interactive system that support the user with information to carry out specific tasks [7].

2.1.3 Iterative Design

No matter how well designers understand the needs of the users, they rarely create the right solution the first time. The design needs to be refined to meet the users' needs and in order to achieve this, iteration is inevitable in a design process. Ideas will probably have to be revised based on users' feedback several times. Innovation takes time, development, trial and error and a lot of patience. [5, p. 49]

2.2 Design Principles

Design principles are a set of considerations and guidelines that are widely applicable. Design principles represent gathered wisdoms of researchers and experienced designers, and by applying them one can predict how users are likely to react to a design. They are fundamental pieces of advice to help teams with decision making and form the basis of any pleasurable design. [8]

2.2.1 Principles for Universal Design

The principles for universal design aim to guide designers to better integrate features that meet the needs of as many users as possible [9]. They empathize that one should take into consideration that people of older age, with different cognitive capabilities, interpretations etc. will use the product, not only standardized users. The Principles of Universal Design consists of seven guidelines:

1. Equitable Use

The design is useful and marketable to people with various abilities. It provides identical means of use for all users when possible, equivalent when not.

2. Flexibility in Use

The design allows for a wide range of individual preferences and abilities.

3. *Simple and Intuitive Use*

It is easy to understand how one should use the design regardless of experience, knowledge, current concentration level or language skills.

4. *Perceptible Information*

Necessary information is effectively communicated to the user, regardless of ambient conditions or the user's sensory abilities.

5. *Tolerance for Error*

The design minimizes hazards and the negative consequences of unintended actions. Warnings and fail-safe features are provided.

6. *Low Physical Effort*

The design can be efficiently and comfortably used with a minimum of fatigue. Repetitive actions are minimized.

7. *Size and Space for Approach and Use*

Appropriate size and space are provided to approach, reach, manipulate, and use the product regardless of the user's body size, posture, or mobility.

Not all guidelines are relevant to all designs [9].

2.2.2 Jakob Nielsen's Ten Usability Heuristics

Jakob Nielsen's usability heuristics consist of ten general principles for interaction design. They are called "heuristics" because they are broad rules of thumb rather than specific usability guidelines [10]. The heuristic evaluation is a method for finding the usability problems in a user interface design and involves a small set of evaluators examining the interface and judging its compliance with the usability principles [11]. Some of the principles are however applicable on hardware as well and will thereby not only be used for evaluation of the application.

Nielsen Norman Group

Jakob's Ten Usability Heuristics

1 Visibility of System Status

Designs should keep users informed about what is going on, through appropriate, timely feedback.



Interactive mall maps have to show people where they currently are, to help them understand where to go next.

2 Match between System and the Real World

The design should speak the users' language. Use words, phrases, and concepts familiar to the user, rather than internal jargon.



Users can quickly understand which stovetop control maps to each heating element.

5 Error Prevention

Good error messages are important, but the best designs carefully prevent problems from occurring in the first place.



Guard rails on curvy mountain roads prevent drivers from falling off cliffs.

8 Aesthetic and Minimalist Design

Interfaces should not contain information which is irrelevant. Every extra unit of information in an interface competes with the relevant units of information.



A minimalist three-legged stool is still a place to sit.

3 User Control and Freedom

Users often perform actions by mistake. They need a clearly marked "emergency exit" to leave the unwanted action.



Just like physical spaces, digital spaces need quick "emergency" exits too.

6 Recognition Rather Than Recall

Minimize the user's memory load by making elements, actions, and options visible. Avoid making users remember information.



People are likely to correctly answer "Is Lisbon the capital of Portugal?".

9 Recognize, Diagnose, and Recover from Errors

Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.



Wrong-way signs on the road remind drivers that they are heading in the wrong direction.

4 Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.



Check-in counters are usually located at the front of hotels, which meets expectations.

7 Flexibility and Efficiency of Use

Shortcuts — hidden from novice users — may speed up the interaction for the expert user.



Regular routes are listed on maps, but locals with more knowledge of the area can take shortcuts.

10 Help and Documentation

It's best if the design doesn't need any additional explanation. However, it may be necessary to provide documentation to help users complete their tasks.



Information kiosks at airports are easily recognizable and solve customers' problems in context and immediately.

NN/g

www.nngroup.com/articles/ten-usability-heuristics/

Figure 2.1: Jakob's Ten Usability Heuristics. Adapted from <https://www.nngroup.com/articles/ten-usability-heuristics/>.

2.2.3 Don Norman's Design Principles

Don Norman is one of the leading thinkers on user-centered design and his main idea is that devices, interfaces and everyday things should be functional, easy to use, and intuitive. He has formulated the seven-stage model of the action cycle [12, p. 71], which provides a checklist of seven questions to ask when designing. Each stage requires its own design strategy and based on this, seven fundamental principles of design [12, p. 72] has been formulated by Don Norman:

1. *Discoverability*

Discoverability is about whether one can figure out in what state the device is in, what actions are possible as well as where and how to perceive them. The relevant components must be visible and communicate what actions are possible. Too many functions and controls are confusing and lead to a messy display [12, pp. 3-4]. It should thereby be estimated what elements are the most important for the user experience, and their visibility should be prioritized.

2. *Feedback*

Feedback is some way of letting the user know that the system is working on their request. The feedback must be clear since uninformative feedback can be disturbing rather than helpful. It should communicate the result of an action and must be immediate since even a small delay can be disconcerting. [12, p. 23]

Too much feedback can be more annoying than too little and excessive announcements often entail that people ignore all of them or, if possible, disable them. This means that critical information is apt to be missed. Feedback is essential but should not get in the way of a calm and relaxing environment. It has to be planned and prioritized so that unimportant information is presented in an unobstructive matter while important information is presented in a way that catches the user's attention. [12, pp. 23-25]

3. *Conceptual Model*

A conceptual model is an explanation of how something works, usually highly simplified. It does not necessarily have to be complete or accurate, as long as it is useful. Files, folders, and icons that are displayed on your computer are metaphors that help create a conceptual model. There are actually no folders inside the computer, but the folder metaphor is an effective conceptualization that eases the use of the system. [12, p. 25]

4. *Affordances*

The term affordance refers to the relationship between a physical object and its user. The presence of an affordance is jointly determined by both the qualities of the object and the abilities of the interacting user [12, p. 11].

5. *Signifiers*

To be effective, the presence of an affordance must be discoverable. If it cannot be perceived, its presence must be signaled in some way. The signaling component is called a signifier. Affordances are the true properties of an object/what it can do, and perceived affordances are what one thinks the object can do, perception. Signifiers clarify affordances and close the gap between the true and perceived affordances. They often make the intended way of using an object more explicit since they communicate how to use the design. Introducing signifiers to make affordances visible to the user is an important part of UX design and provide clues about how to use the product. [12, pp. 12-20]

6. *Mapping*

Mapping refers to the relationship between the control and the effect it has on the world - which control is connected to what action. It is an important concept in designing control layout and display. In the best possible scenario, there would be no need for labels for which control works which function, because the natural mapping facilitates immediate understanding. Trial and error should not be necessary since the connections are obvious. [12, pp. 20-22]

7. *Constraints*

Constraints are clues that limit the possible actions. Both physical, logical, semantic, and cultural constraints can be provided to ease interpretation [12, pp. 125-130]. Physical constraints limit what actions can be done and when using well-thought-out constraints in design, it guides people towards the appropriate actions even in a novel situation [12, p. 125].

2.3 Methods

2.3.1 Interviews

Interviews allow direct contact with potential end users. They can be highly structured by following a script of questions, unstructured by allowing detours [13, p. 102] or something in between. Semi-structured interviews are in the middle of the spectrum of how much control the interviewer imposes on the conversation. It combines features of structured and unstructured interviews and includes both open and closed questions. Open questions mean that there are no expectations about the content of answers, while closed questions require an answer from a set of alternatives. Open questions can generate rich data and issues that the interviewer has not considered. Closed questions are however easier to analyze. In semi-structured interviews, the interviewer follows a script to make sure to cover the same topics with each interviewee [5, p. 269].

2.3.2 Personas and Scenarios

Personas [5, pp. 403-404] and scenarios [5, pp. 408-410] are two techniques that are commonly used to bring requirements to life and to augment the basic required information. They are often used together and allow the developer to bring realistic detail to explore the user's current activities, future use of products, and futuristic visions of new technology [5, p. 403]. A persona characterizes a typical user, and a scenario characterizes the use of the product or an example of achieving a goal [5, p. 414].

2.3.2.1 *Personas*

In user-centered design, it is advantageous to precisely define the characteristics of future users to ensure that the product being designed matches these characteristics [14, p. 21]. Based on data gathering, such as interviews or questionnaires, personas can be created. Personas should be realistic and represent a number of real users who have been involved in the data gathering, by studying behavioral patterns and themes that constitute commonalities [13, p. 132]. The result should be detailed, concrete descriptions of typical users of the product under development. These are fictitious users that designers can focus on and design the product for [5, p. 403].

Each persona is characterized by unique goals related to the product and is proved to be a powerful way to communicate the users' goals and characteristics to the designers. The persona commonly includes a name and a photograph or sketch, user quotes, key goals, behaviors, and some background information. The rich, credible

details are what helps designers see the personas as real potential users. [5, pp. 403-404]

2.3.2.2 *Scenarios*

A scenario is a story exploring the future use of the product from a user's perspective to help the design team reason about its place in a person's life [13, p. 152]. It describes in detail what a user does and *why* they do it. It is a short story of a person who uses a product with a certain motivation and a specific goal in mind. Scenarios reflect plausible futures, usually in conjunction with a backstory and the development leading to them. When using scenario analysis, decisions can be evaluated by confronting them with potential future environments [15].

A scenario empathizes the context, the usability and the user experience goals as well as the activities in which the user is engaged. It captures only one perspective but can help provide indicators of potential design choices for the new system. A scenario focusing on how a new product may be used can help uncover implicit assumptions, expectations, and situations in which the users might find themselves [5, p. 410]. Scenarios can be created as storyboards, written stories or full-scale movies [14, p. 23]. A scenario empathizes the context, the usability and the user experience goals as well as the activities in which the user is engaged. It captures only one perspective but can help provide indicators of potential design choices for the new system. A scenario focusing on how a new product may be used can help uncover implicit assumptions, expectations, and situations in which the users might find themselves [5, p. 410]. Scenarios can be created as storyboards, written stories or full-scale movies [13, p. 23].

3 Design Process

The project was initiated by evaluating Phonirol's products from a UX perspective. One of the products, Medic Mini, was chosen for development and the process was followed by conducting interviews to gather data from regular users, in order to identify needs and create personas. Based on the personas and needs, concepts were generated both individually and together. The chosen concepts were implemented in a prototype. The prototype was tested on users and, since an iterative design process was practiced, re-designed based on the user opinions. After three iterations of tests and prototyping, the final proposition was reached. The entire process was finished off by evaluating the proposition with a final round of user tests.

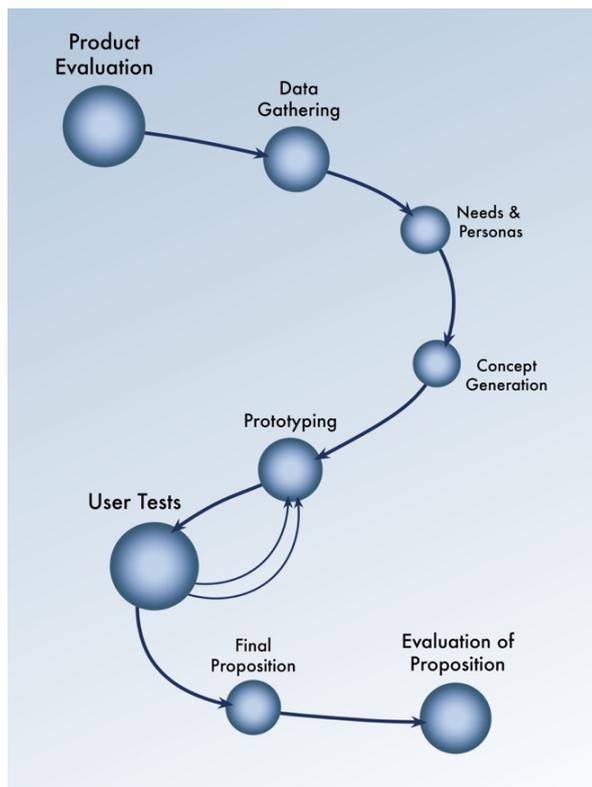


Figure 3.1: Flow chart of the design process.

4 Product Evaluation

This section covers the evaluation of the existing products received from Phoniro. It begins by presenting the lists of that were later compiled into the final evaluation form. The results of the evaluation for each product are declared and finally, the chosen product for future development and its scope is presented.

4.1 Compilation of Design Principles

Several different methods were explored when researching what evaluation methods were suitable for the products received from Phoniro AB. Using personas [5, pp. 403-404] and scenarios [5, pp. 408-410] was considered but it was estimated that these methods would be more usable at a later stage in the process. After some thinking and a bit of discussion with the project supervisor, it was decided to create a customized list of heuristics to conduct a heuristic evaluation with as relevant points as possible. Three widely accepted lists of guidelines were used for inspiration when creating the customized heuristics:

1. The Principles for Universal Design [9]
2. Jakob Nielsen's Ten Usability Heuristics [10]
3. Don Norman's Design Principles [12]

The three methods empathize different things but are similar in many ways. They all seemed relevant to the evaluation in their own way.

4.2 Final Evaluation Form

Relevant guidelines from the three heuristic evaluation methods were compiled into a customized list. What started as 24 principles ended up being 14 after the compilation. Many principles have one or more subprinciples. The full list of all evaluation points can be found in Appendix B. Just like in each and every one of the methods, there will always be many principles relevant to a product, but all principles will not be applicable to all products. The 14 principles in the compiled

and modified evaluation are listed in Figure 4.1, together with a short explanation of every point:



Figure 4.1: The final principles for the product evaluations.

4.3 Evaluation

Generally speaking, it is difficult for a single individual to perform a heuristic evaluation, since they will never be able to find all usability problems. It has however been shown that different people find different usability problems and it is therefore possible to improve the effectiveness of an evaluation significantly by involving multiple evaluators [11]. Because of this, individual evaluations were initially performed by the two team members. Conversations regarding problems found were avoided and not before all evaluations were finished was the team allowed to discuss what they had discovered with each other. The evaluation process was finished off by joining the individual evaluations into a common one. After completing the product evaluation, a product was chosen for further development.

The evaluation of the medicine cabinet, Medic Mini, was performed differently than the evaluation of the other products. The reason for this was that the medicine cabinet was not a complete and functioning product, and thereby more complicated to evaluate. The user sequence of an old model had been filmed at the product pick up at Phoniro AB and was used to evaluate the product's function. It did not enable as detailed an evaluation, but it made it possible. The feeling of opening and closing the cabinet was also hard to evaluate due to the lack of a knob. Both team members were unsure how to proceed with this more challenging evaluation and it was thereby decided to do a joint evaluation of the Medic Mini.

4.3.1 Product Design Overview

An overview of the received products was done to get a picture of Phoniro's general product design theme. It was concluded that all products had a minimalist design with discrete colors. Simple shapes with sharp edges were common to the Key Safe and Medic Mini while the Phoniro Lock was a bit different with its rounded edges and sweeping shapes. All products were mostly black, grey and silver. The minimalist design was further expressed in the few visible details. Only the logo and the necessary components, mediating feedback and how to interact with the product, were visible.

4.3.2 Phoniro Lock

The Phoniro Lock is mounted on the inside of the care receiver's door and replaces the standard locking knob. It can be unlocked and locked via the app as well as manually.



Figure 4.2: Phoniro Lock.

General opinions:

- The knob was not tightened very hard which resulted in a wobbly, rattling rotation. This lowered the overall experience.
- It is possible to rotate the knob an extra 360 degrees. This might have a reason but led to confusion regarding how to rotate the knob and in some positions a trial-and-error kind of problem solving was required.
- The locking/unlocking process was very loud when it was performed via the app.

1. Discoverability

Beyond the Phoniro logo, a button and a knob are visible at first glance. These are the only parts of the product that are not entirely black. Due to their deviating color, these components stand out, hinting that they are available for interaction. There are no unnecessary components visible to the user. The LED only draws attention to itself once it is lit, since it is discretely implemented in the button.

2. Feedback

The feedback available for the Phoniro Lock is a LED (the colors noticed are blue, green, and red), beeping sounds, engine noises and the sound of the bolt moving in or out when the door is locked or unlocked. The button and the knob also provide tactile feedback when they are pressed or rotated.

Only when one performs a battery test manually is audial feedback provided, in the form of beeping sounds. Apart from this, the only sounds hinting to the user what happens is the sound of the moving bolt and the engine noises. The sound for locking/unlocking is more or less the same for both actions. The LED implemented in the button, which is the primary source of feedback, can only be seen from inside the door since that's where the product is mounted. The LED feedback for locking and unlocking via app is identical. When one unlocks or locks manually, by turning the knob, no LED feedback is given at all.

When the LED lights green, the system is working on the locking/unlocking. Once it blinks red twice, the process is finished. As previously mentioned, the feedback is the same for both processes and the user is thereby not informed whether the system just locked or unlocked the door. There is also no feedback of whether the door is unlocked or locked once it is in a still state. One has to pull the handle to check whether the door is locked or not.

When one checks the battery manually, by pressing the button for five seconds, the LED lights blue and the Lock simultaneously beeps 11 times. It then lights green for a few seconds before it blinks red twice. Since there previously had been no audial feedback, the repeated beeping mediated the feeling of something going very wrong. The fact that what happened was not mediated in the app made it difficult to understand what was going on. Only when asking the company supervisor, was it understood that a simple test of the battery had been done.

There are no explanations of what the different kinds of feedback mean. In general, red is an indicator to wait, or that something went wrong. In the Phoniro Lock this is instead an indicator of successfully completing a task. This applies to both the locking/unlocking and finishing of the battery test. Since it is unclear what the feedback is trying to mediate in several cases, the feedback is partly insufficient and ineffective.

3. *Conceptual Model*

Since the knob looks like a standardized knob, one creates a mental model of how the system works based on one's previous experience of similar locks.

4. *Affordances*

The Phoniro Lock affords locking and unlocking, both manually and via app. The knob affords turning to lock/unlock the door and the button affords to be pressed.

5. *Signifiers*

The button has a rubber-like surface and is slightly elevated. This makes it look and feel like a button. The classic appearance of the knob indicates that turning, and not pulling or pushing, is supposed to be performed to unlock the door. The deviating color of the knob and button indicates that these are the components one should interact with.

6. *Mapping*

There is no clear relationship between the button and the functions it controls.

7. *Constraints*

There are not any unnecessary components available for interaction. Redundant components and information will only confuse the user.

8. *Equitable use*

Only home care staff will use the app to lock and unlock. It is possible for the care receivers to open the Lock with their ordinary key or by rotating the knob from inside the door, just like in any ordinary lock. The knob is big and easy to grip. The low friction makes it easy for anyone to rotate the knob.

9. *Flexibility in Use*

The possibility to mount the construction upwards or downwards makes it possible to mount the Phoniro Lock on various doors.

10. *Tolerance of Errors*

Testing the battery via the app unlocks the door. This is not announced in any way and unintentionally unlocking the door is thereby a possible error.

11. Low Physical Effort

Due to the design of the knob, one naturally grips it from two sides. This allows for a steady grip where the user is in control of the movement. The extra rotational possibility might entail unnecessary physical effort. However, little momentum is needed to turn the knob.

12. Size and Space for Approach

The knob is easy to grip for people with both small and big hands. The button is easily accessed.

13. Consistency and Standards

The design of the knob is standardized, and it is thereby easy to understand how to use it. The LED feedback of the Phoniro Lock is however very unclear and not consistent with the company's newer products.

14. Help and Documentation

Mounting instructions are available. A user manual was not received or found.

4.3.3 Phoniro Key Safe

The Key Safe stores keys securely and can only be unlocked via the app – unlocking the Key Safe manually is not possible. It locks itself automatically when closed. Only the staff have access to unlock it.



Figure 4.3a-b: Phoniro Key Safe.

General opinions:

- It is a bit difficult to understand how to open Key Safe when it is not mounted on a wall.
- Some force is required to pull down the key storage.

1. Discoverability

A logo and a LED indicator are visible at first glance. The LED is off when no interaction occurs. The key storage, which is the only moveable part, is of a different material and color, hinting that it is a separate part. However, it is not very clear how to interact with it.

2. Feedback

The feedback available for the Key Safe is, apart from the feedback in the app, a LED (the colors noticed are blue, green, red, orange and purple) and engine noises. During the unlocking process, the LED lights blue during the authentication. The LED turns off and a faint engine noise can be heard during the unlocking. When it is unlocked and can be opened, the LED lights green. The green LED is on for about 6 seconds. As long as the LED lights green, the Key Safe does not lock itself when closed. When the LED is off, it can still be opened for one minute before it locks automatically. When it locks, the same engine noise can be heard again and then the red LED lights for a few seconds. The LED also lights orange if something goes wrong but *what* went wrong is not communicated. Sometimes the LED lit purple, but the reason could not be understood. Perhaps, an additional kind of feedback would have been desirable.



Figure 4.4a-c: The blue LED is on during the authentication. The LED lights green when the Key Safe is unlocked and red when it is locked.

3. Conceptual Model

One can think of the Key Safe as a drawer that opens vertically instead of horizontally.

4. Affordances

The Key Safe affords to unlock via app and locks itself automatically. The key storage affords removal and reinsertion, opening by pulling and closing by pushing. The hook affords to hold a key.

5. *Signifiers*

One must open the Key Safe manually since it does not automatically slide open once it is unlocked. It is not obvious how to open the Key Safe. The deviating color of the key storage hints that it is a separate part, but the handle is not visible to the user. A possible alternative to open the safe could be to remove the silver part, but the lack of a grip surface hints that this is not the appropriate action. Its placement on the wall also suggests that one should pull the black part down. There is only one natural place to grasp the handle and once it is found it is pretty straightforward how one should pull. However, the high friction causes uncertainty since one feels like pulling it might break it. Perhaps, an arrow pointing down would be a good addition, to make the action more obvious.

It would be very difficult to figure out how to remove the key storage without instructions. However, it is not performed frequently since it is only necessary when mounting the safe or changing the battery.

6. *Mapping*

Not applicable.

7. *Constraints*

The key storage cannot be removed by simply pulling with force. The hook inside the Key Safe minimizes the risk of the key falling out when it opens. Without the hook, there is a high risk of the key falling out. Unlike the Phoniro Lock and Medic Mini, the Key Safe does not have a button. However, a button is not necessary for the Key Safe. Redundant components and information will only confuse the user. The range of possible interactions are limited by the minimalist design.

8. *Equitable use*

It is difficult to open for people with weak hands. The removal of the key storage is difficult for a person with big fingers or weak nails.

9. *Flexibility in Use*

The design does not allow for individual preferences or abilities.

10. *Tolerance of Errors*

If the battery is discharged, the LED cover can be removed and the safe can be powered via an external battery. If the Key Safe is accidentally unlocked, it automatically locks itself after one minute. The Key Safe is supposed to lock itself

when it has been opened and closed once. However, if it is opened and closed before the app announces that the unlocking was successful, it can be re-opened. If it is pulled out simultaneously as the safe tries to lock itself, there are various outcomes that may occur. It either resulted in the Key Safe locking itself in an open position, in an in-between position or in the locking being interrupted and then continued once the safe was properly closed again.

11. Low Physical Effort

Due to the high friction when one pulls down the key storage, it is not effortless to complete the action. To completely remove the key storage, it requires pulling the latch inside the safe to the left. The latch is difficult to reach and thereby requires a lot of effort to push sideways. The removed storage and the latch can be seen in the figure below.



Figure 4.5: The key storage is removed. The red arrow points to the latch that must be pulled to the left in order to remove the key storage.

12. Size and Space for Approach

The handle can be grabbed with two or three fingers depending on the user's finger size. The compartment for the key is quite small and a person with big fingers might have difficulties gripping a key hanging inside it. As one can see in Figure 4.5, the same user might also have difficulties pushing the latch sideways since it is difficult to access the latch even with small fingers. Weak nails and/or fingers complicate the maneuver even more. Pushing the latch sideways is however easier after doing it a few times since it is not intuitive and requires a bit of technique. If the latch were to be placed further to the left, the action could have been eased.

13. Consistency and Standards

The LED feedback in the Key Safe is not the same as in the Phoniro Lock. However, the Key Safe is a newer product with new LED colors implemented. These were considered more straightforward than the previously used LED colors, which were used in Phoniro Lock.

14. Help and Documentation

An installation manual is available. It states how to change the battery, how to dismantle the Key Safe and how to open it in an emergency, if the battery is discharged. It also explains that the green LED lights when the lock is unlocked, and it is possible to pull down the key compartment to open the safe. The red LED lights when the Key Safe is locked.

4.3.4 Phoniro Medic Mini

Medic Mini stores medicine securely and can only be unlocked via the app. Only the staff have access to unlock it. Since the Medic Mini received was not a complete and functioning product, the user sequence of an old model had been filmed and was used to evaluate the digital opening of the product. The feeling of opening and closing the cabinet was hard to evaluate due to the lack of a knob. The feedback was also hard to evaluate since the old model lacked LED feedback, which however would be implemented in the updated product.



Figure 4.6a-b: Phoniro Medic Mini.

General opinions:

- It was hard to evaluate the opening due to the lack of a knob.
- Some damping is implemented but it could be better since the overall experience was deteriorated by the rattling noises.

1. Discoverability

In the first product, there was no LED feedback. This is however planned to be implemented in the new edition and a LED, a button and a knob will thereby be the visible components. Due to the dark grey color of the medicine cabinet, the dark color of the button does however not stand out. Just like in the previously evaluated

products, Medic Mini has a minimalist design with only necessary components visible.

To open the cabinet, one must both press the button and unlock via the app. In what order to perform these actions is not obvious just by looking at the product.

2. Feedback

The feedback available will be LED feedback, tactile feedback, visual feedback as the door pops open as well as mechanical sounds of the locking and unlocking.

Since there is no actual LED implemented in the current product, it was not possible to evaluate the LED feedback. The tactile feedback of pressing the button was however clear. The mechanical sound that occurs when the button is pushed down is not pleasing but makes it clear that the button has been successfully pressed. Based on the assumption that the mechanism of the new cabinet will be the same as for the first one, a faint clicking sound will let the user know that the cabinet is locked. This might be difficult to hear for a person with bad hearing but also for everyone in a room with surrounding noise. Added LED feedback will probably solve this problem. Successful unlocking of the new cabinet will be obvious since the door is supposed to pop open once it is unlocked.

Once the door is closed or fully opened, one can hear a clanking sound when the arms hit the metal plate that is keeping the door in its wanted position. The arms can be seen in Figure 4.6b. This is unpleasing, and damping should probably be implemented to enhance the experience.

3. Conceptual Model

One thing that is not intuitive is whether one should push the button before unlocking via the app or the other way around. If one presses the button first, one could think that the button wakes up the Medic Mini, making it detectable in the application. If it works in the opposite way, one could say that the user opens the cabinet with the button. Which mental model is the right one depends on the intended way of interaction.

4. Affordances

The button affords to be pressed and the lock affords locking and unlocking. The door affords opening and closing and the cabinet affords storing.

5. Signifiers

The button is elevated and stands out due to its deviating color. This indicates that it can be pushed. The axis of rotation is visible at the bottom of the medicine cabinet

and hints that the door opens downwards. In the first edition, one is supposed to turn the handle before it is possible to open the door. As one can see in Figure 4.7, the shape of the knob indicates the possible rotation and the shape of the knob in the second edition should thereby indicate that pulling is the only method necessary to open the door.

The flat surface at the bottom signifies that one can put stuff on it. It however indicates that the entire surface is at disposal even though it is not possible to put things at the edges since the arms on the door require that space to be free in order to properly close.



Figure 4.7: Phoniro Medic, the first edition.

6. Mapping

The mapping between the button on top of the medicine cabinet and the opening of the medicine cabinet is not clear.

7. Constraints

Just like in the previously evaluated products, the Medic Mini has a minimalist design without any irrelevant components that the users might accidentally interact with. The door automatically stops in a horizontal position due to the arms on the side, preventing the door from hitting the surface that the medicine cabinet is standing on. Metal plates are also placed inside the cabinet, at the top, to stop the door in a vertical position.

All the space presented as available for storage is actually not at disposal. In order for the door to close properly, one has to leave room for the arms on the sides. This is not noticeable when the cabinet is open and might lead to frustration since one does not know where “the storage stops”. Wrong placement of the items in the cabinet will make it impossible to close the door.

8. Equitable use

A faint clicking noise can be heard to confirm the locking. This can be hard to hear for a person with bad hearing or when there are surrounding noises. Added LED feedback can probably solve this problem.

9. Flexibility in Use

The design does not allow for individual preferences or abilities.

10. Tolerance of Errors

Nothing happens if one presses the button without also unlocking via the app. Due to the button, unlocking the wrong cabinet is impossible. Nevertheless, one could accidentally unlock the cabinet and then one must probably close the door to make sure it locks itself. It is unclear if the cabinet locks itself after a certain time without being manually closed, but probably not considering that it pops open when it is unlocked.

11. Low Physical Effort

The lack of a knob made it difficult to open the door of the Medic Mini, but this will probably not be an issue when a knob is in fact mounted on the door.

12. Size and Space for Approach

Appropriate size and space are provided to use the cabinet. Whether this is still true when the Medic Mini is mounted inside a bigger medicine cabinet is hard to predict.

13. Consistency and Standards

The design is consistent with Phoniro's minimalist design. The button looks and feels like a regular button. The copy evaluated lacked a knob to open the cabinet, but this will be implemented in the final product.

14. Help and Documentation

Instructions regarding how to unlock and lock the medic cabinet is provided in a user manual. The manual states that the staff has to press the unlock-button in the app within five seconds after pressing the button on the top of the medicine cabinet. It also states that a faint clicking noise can be heard to confirm the locking.

4.3.5 Phoniro Home Care App

When home care staff is visiting the care receivers, the app is used to lock and unlock the Phoniro Lock while it only unlocks the Key Safe and Medic Mini. The approach to unlock the different products via the app is the same: choose the name of the care receiver and then press the unlock-button below the product name.

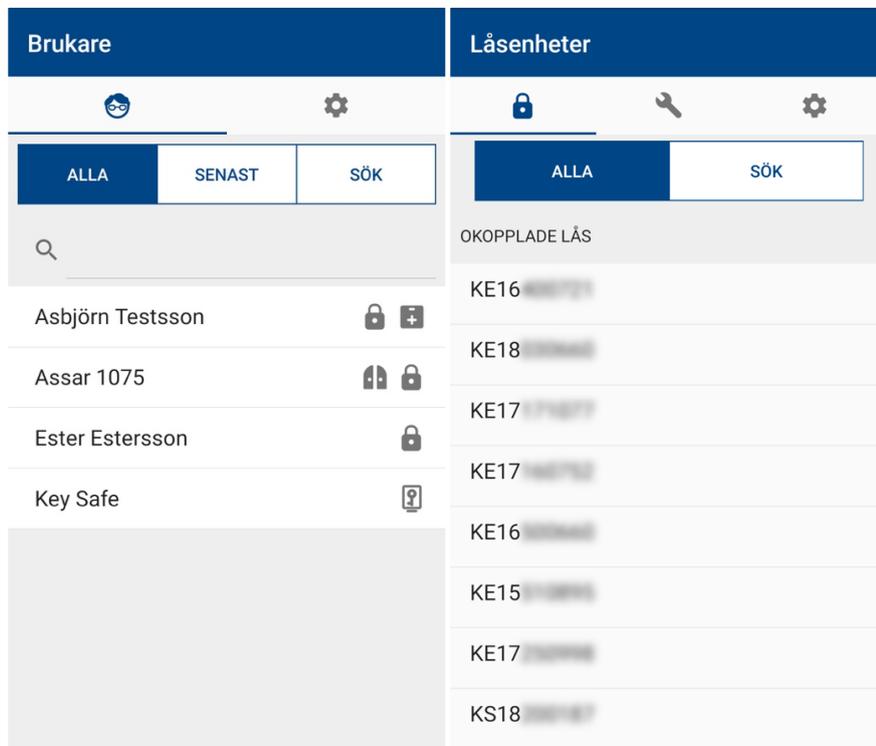
General opinions:

- The feedback mediating that a button *is being* or *has been* tapped varies in the application. Dark blue, grey, and orange are used as feedback colors, but sometimes the color of the button does not change at all.
- Several messages are announced throughout the unlocking process. Some are redundant.

1. Discoverability

The main, horizontal menu is displayed at the top of the screen. For the staff, the main menu has two icons: a person's head and a gear, which can be seen in Figure 4.8a. The head represents the care receivers. Additional tabs are shown when the head icon is tapped: "Alla"/"All", "Senast"/"Most recent" and "Sök"/"Search". When the tab "All" is activated for the staff, all care receivers belonging to the organization are displayed and alphabetically sorted in the list. The care receiver's locks are shown regardless of whether they are close enough to interact with, or not. When the tab "Most recent" is activated, care receivers are sorted after whose lock was interacted with most recently. The products installed in their respective homes are shown by icons next to their names, when either the tab "All" or "Most recent" is activated. In the mentioned tabs, it is possible to search for care receivers by typing their names.

For the installer, the main menu has three different icons: a padlock, a wrench, and a gear, which can be seen in Figure 4.8b. For the installer, the padlock represents locking devices. The additional tabs shown when the padlock icon is chosen are "All" and "Search". The tab "All" displays unpaired locks represented by their serial numbers and are not alphabetically sorted. Icons that describe what kind of product the serial number represents do not exist. The installer cannot search for care receivers or serial numbers by typing.



a) The staff view

b) The installer view

Figure 4.8a-b: The different layouts in the main menu for the two types of users. The icons next to the care receivers' names represent the products installed in their respective homes.

When the tab “Sök”/”Search” is activated, it is possible to search for locking devices nearby, using Bluetooth. Devices one cannot interact with, such as computers or headphones, are also detected when the installer searches for locks. The staff, on the other hand, can only detect already registered care receivers.

When selecting a care receiver, staff members are automatically directed to the sub-tab “Lås”/“Lock”. The sub-tab “Info” is also available for the staff, while only one tab, “Lock”, is available for the installer. The name of the selected care receiver is visible in the page header to the staff, while only the serial number of the product is visible to the installer. The first letters in the serial number hint what kind of locking device the installer is dealing with, but it does not explicitly say what product it is. Options are hiding deeper in the app and the main menu is not visible for neither the staff nor the installer when one is on the care receivers' or the locks' page.

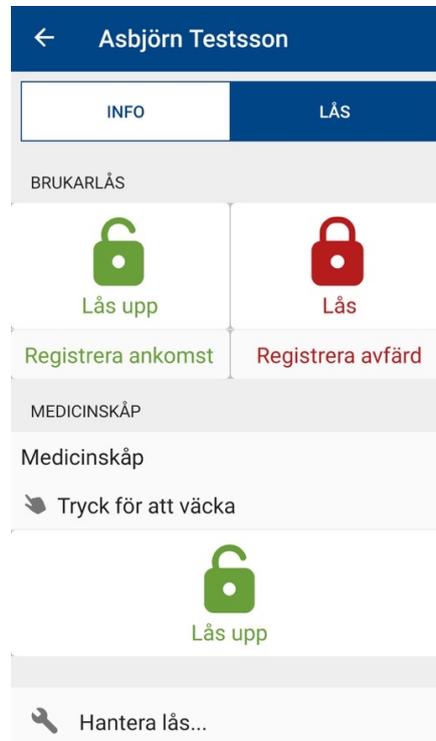


Figure 4.9: When selecting a care receiver, the products that are installed in their home are shown. The main menu is no longer visible. Above the unlock-button for the medicine cabinet, it says “Press to wake” to inform the user about the action required to be successfully unlock.

Frequently used buttons, like unlock and lock, are bigger than less frequently used ones. They are placed high on the page, making them easily accessed. Whether the lock is locked or not is not visible in the app. Sometimes the user is required to perform a physical action in order to be able to lock or unlock via the app, for example push a button on the product. If this is necessary, a prompt is visible, and this can be seen in Figure 4.9.

To log out, one must go into the settings tab (represented by a gear, see Figure 4.8) before the log out-option is visible.

2. Feedback

Loading Wheel

The actions currently performed by the system is continuously communicated through feedback. After tapping the unlock-button, the unlocking process begins. Several messages are announced throughout the process, making one unwilling to

read any of the messages since they pass by so quickly. The messages that are shown can be seen below.



Figure 4.10: Flow chart of the messages displayed on the screen during the unlocking process.

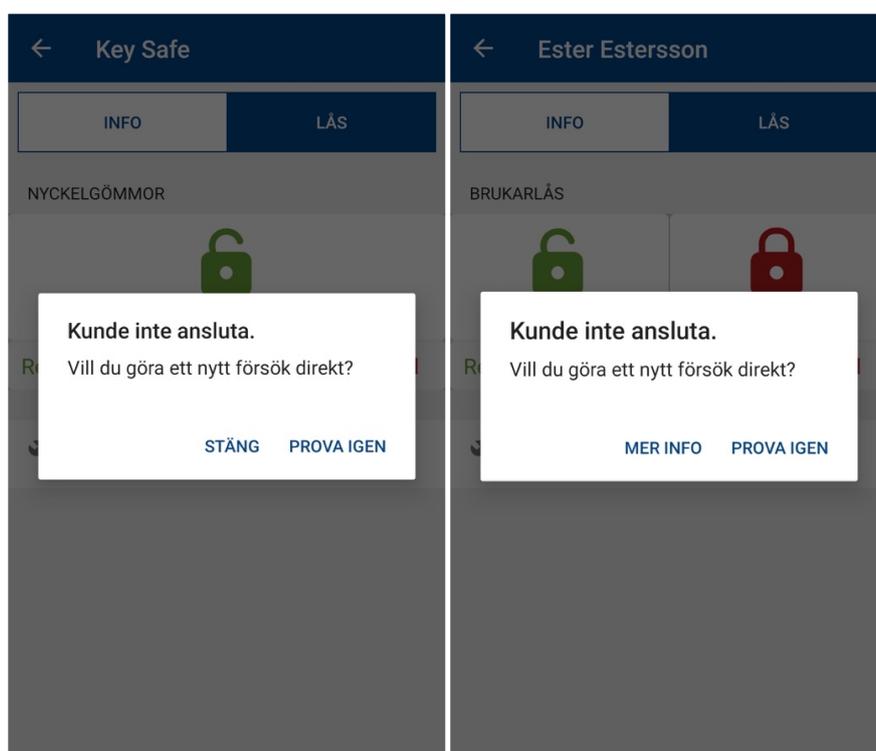
The app announces “OK att öppna”/“OK to open”, when the lock can be opened. It has the same design as the loading messages and does not draw attention to itself, entailing that it is likely to be overlooked. It is also replaced by the message “Slutför...”/“Completing...” after only a moment. The messages give the impression that the product cannot be opened before the message “Lyckades”/“Succeeded” appears. The messages “Completing...” and “Succeeded” adds no new information and are thereby redundant.

When the locking process is finished for the Phoniro Lock, this is not mediated in the app. No pop-up corresponding to the “OK to open”-message is implemented. The messages shown are “Låser...”/“Locking...”, “Completing...” and “Succeeded”. However, the product is locked before the last two messages are shown on the screen.

Pop-up window - “Could not connect”

If there is a problem when connecting to a lock, a pop-up window appears announcing “Could not connect. Do you want to make a new attempt immediately?”. Depending on which product one is trying to unlock, different options are available and can be seen in Figure 4.11. If the option “Prova igen”/“Try again” is selected, the app retries to connect to the lock and the same pop-up window appears if it fails again. If the option “Mer info”/“More info” is selected for the Phoniro Lock, a list of possible sources of error is displayed to help troubleshoot the problem and the options “Stäng”/“Close” and “Try again” are available (see Figure

4.12a). A tap outside the pop-up windows directs to the option that is *not* “Try again”. When the option “More info” is available, this is where one is directed and when the option “Close” is available, the window closes.



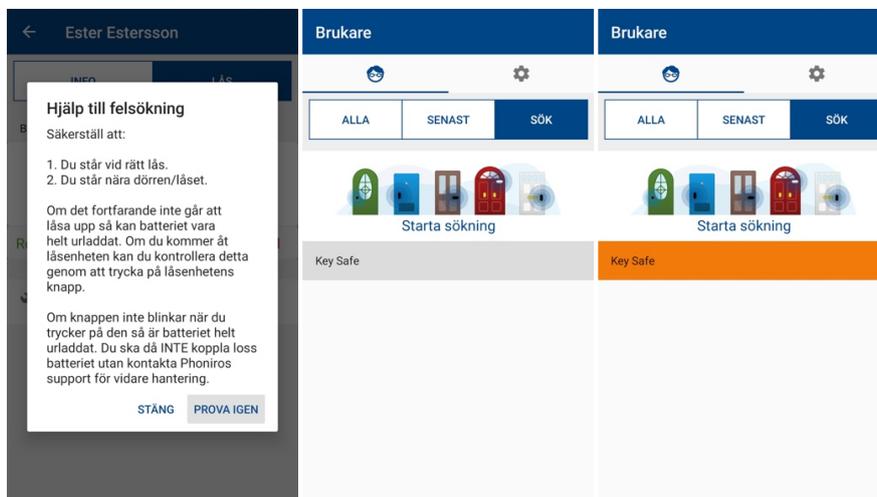
a) The message for the Key Safe

b) The message for the Phoniro Lock

Figure 4.11a-b: The difference between the options available in the same pop-up window for different types of products. For the Key Safe, the options “Close” and “Try again” are shown, while the options are “More info” and “Try again” for the Phoniro Lock.

Buttons

The feedback mediating that a button *is being* or *has been* tapped varies in the application. The log in-button turns dark blue once it is pressed, indicating that it is about to be activated, while some other buttons turn grey when they are pressed. This applies, for example, to the possible options in a pop-up window and when selecting a care receiver after a search using Bluetooth. The button with the care receiver’s name turns orange when it has been tapped and stays orange until another care receiver in the list is selected or a new search has begun. Orange feedback is not found anywhere else in the app.



a) Help to troubleshoot b-c) Search for locking devices nearby using Bluetooth

Figure 4.12a-c: The selected option in a pop-up window turns grey when pressed, and the window disappears when an option has been tapped. The selected care receivers' name turns grey when it is pressed and orange when it has been tapped.

Some buttons do neither change color when they are about to be activated nor when they have been activated. However, a loading wheel appears, mediating that the button has been tapped. This applies, for example, when tapping a care receivers' name for the staff or an unpaired lock for the installer, as well as when one taps the unlock/lock-buttons. During the unlocking/locking process, messages are announced below the loading wheel, shown in Figure 4.10. The process can be canceled during the connection phase, shown in the first message. The button "Avbryt"/"Cancel" does not look clickable, since it has the same appearance as the messages.

Tabs

The tabs in the main menu do not change color when they are pressed but do however let the user know once they have been activated since a blue line appears below the tab simultaneously as the icon turns blue. The tabs "All", "Most recent" and "Search" turn grey once they are tapped on and dark blue when they are activated. The sub-tabs "Locks" and "Info" have the same feedback as the previously mentioned tabs.

Input fields

When one presses an input field where one enters username or password, it receives a dark blue outline. The field's icon also turns blue, and a blinking insertion point

appears in the field. When one chooses the field where one searches for care receivers by typing, it only receives a blinking insertion point. Pressing the icon placed in the input field does not activate it, one must press the blank space next to it. Regardless of which field one chooses, the keyboard appears on the screen.

3. *Conceptual Model*

The green and red padlocks in Figure 4.9 are metaphors for the locking/unlocking of the devices. The metaphors are not correct, but obvious. The green, open padlock symbolizes unlocking and the closed, red padlock symbolizes locking. The unlocked/locked padlock is probably more straightforward than icons of an open/closed door.

The icons next to a care receiver's name in Figure 4.8 are metaphors and represent the products installed in the user's home. Here, a padlock represents the Phoniro Lock, a key in a box represents the Key Safe and a first aid bag represents the Medic Mini. As mentioned, the padlock is the icon representing the Phoniro Lock. It is also both a metaphor for unlocking/locking of devices and represents all locking devices for the installer (see Figure 4.8b). The icon's meaning is inconsistent.

The person's head in the main menu in Figure 4.8 is a metaphor for the care receivers. The gear is a metaphor for settings and is recognizable from many other applications. It is a generally accepted symbol for settings in graphical interfaces. The wrench in the main menu in Figure 4.13 is a metaphor for tools, but it is unclear what this symbol represents. By reading the page header, it is understood that it symbolizes software in this case. In other applications, the wrench is sometimes used as a "settings" metaphor. In the Phoniro Home Care app, the wrench is also used as the icon representing "Hantera lås..."/"Lock Settings..." (see Figure 4.9). The icon's meaning is thereby inconsistent. All symbols in the interface have an explanatory text.

In the installer view, a trash can and a vertical arrow can be seen in the software tab, represented by the wrench in Figure 4.13. The trash can is a metaphor for deleting. It is recognizable from many other applications and is a generally accepted symbol for settings in graphical interfaces. The vertical arrow facing a flat surface is a metaphor for downloading and is also of platform standard. The metaphors for the symbols found under settings are too many to evaluate at this stage.

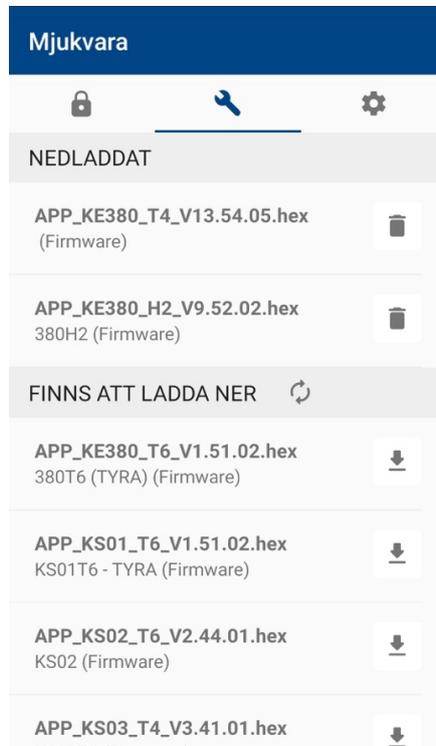


Figure 4.13: The software tab that is available for the installer. The icons to the right, metaphors for deleting and downloading, are recognizable from other applications.

4. *Affordances*

The graphical interface affords scrolling and tapping of buttons. When the user presses the unlock-button, the application affords to unlock the device. In the opposite way, it also affords to lock the Phoniro Lock as well. It does not afford to lock neither the Key Safe nor the Medic Mini. The app also affords to perform a battery test on the Phoniro Lock once the “Testa batteri”/“Test Battery”-button is pressed.

5. *Signifiers*

During the connection process, the cancel-button does not look clickable since it has the same appearance as the messages below the loading wheel (see Figure 4.10). Clickable and unclickable buttons generally have the same colors and appearance in the app.

Both colors and icons are used to hint the functions of the locking and unlocking buttons to the user. The green color signifies “go” and red signifies “stop”. The open padlock mediates to the user that the device unlocks once the button is pressed, while the closed padlock mediates that it locks instead.

Sometimes, the user is required to perform a physical action on the lock in order to be able to lock or unlock via the app, for example push a button. If this is required, a prompt is visible above the buttons to “Unlock” and “Lock”.

In the tabs “All” and “Most recent”, where one can search for a care receiver by typing their name, the word “Search” in the input field would be a good addition to make the field’s purpose clearer.

The scrollbar signifies that scrolling is possible and also lets the user know their current location in the list. A scrollbar is however not implemented in all scrollable pages.

6. *Mapping*

The open and closed padlock provide a clear relationship between the button and the function they control on the physical product since they are common metaphors and known to the vast majority.

7. *Constraints*

In the tab “All”, every care receiver belonging to the organization is displayed, not only the care receivers with locks within interactable range. The list does thereby not limit the range of possible interactions to prevent the user from trying to interact with a lock that is out of range. However, constraints are implemented for the Key Safe and Medic Mini. Since one cannot lock either of them via the app, no lock-button is shown on their pages. This hints that one must lock the device manually and helps guide the users to the appropriate actions.

8. *Equitable use*

In order for the app to be useable for blind people, a complementary system is necessary. The Phoniro Home Care application does however not seem to be optimized for TalkBack. When pressing a button, it reads a long name combined with digits instead of reading what the button says. It is neither possible to unlock the products when TalkBack is activated.

The color of the icons for lock and unlock (see Figure 4.9) is difficult to distinguish for a person with color blindness. The icon designs deviate from one another slightly but the difference could have been clearer to ease the recognition of the correct button.

9. Flexibility in Use

The design allows for some individual preferences. The font size in the Phoniro Care application is correlated to the system font – if the phone’s font size is changed, the font in the application follows. The application also provides shortcuts to speed up the interaction. In the tab “Most recent”, care receivers are sorted by which was interacted with most recently. This facilitates the finding of the right care receiver when the staff uses the app several times during a visit. The map pin icon next to the care receiver’s address directs the user to Google Maps and gives directions. The phone icon by the care receiver’s phone number launches a call to the care receiver. The mentioned icons can be seen in the figure below.

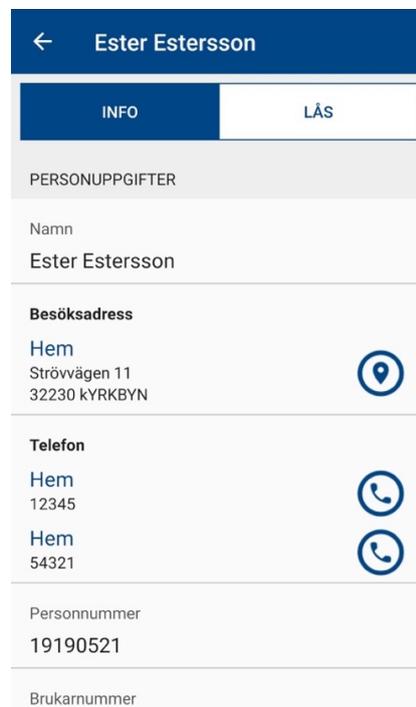


Figure 4.14: The care receiver’s personal data. The map pin icon and the phone icon are displayed to the right. The care receiver is fictitious.

10. Tolerance of Errors

The search function, where one searches for a care receiver by typing their name, is bothersome to use. If one does not type the letters fast enough, the system automatically starts searching based on the current typed letters and also removes the keyboard. It does not allow the user to take even a brief pause but forces them to type continuously. Also, after removal of all letters, either manually or by

pressing the cross in the field, one has to start typing immediately. Otherwise, the keyboard will disappear, and all care receivers will appear on the screen again.

There is a difference in the search function depending on which tab is active. In the tab “All”, both “Testsson” and “Ester” appear when one searches for “est”, while in the tab “Most recent” the first letters of a name have to be written in order to find the right care receiver. Searching for “afe” gives no results, but a search for “Ke” or “Sa” results in “Key Safe” appearing on the screen.

When the user enters the page of a lock or care receiver, there is a back button at the top left, enabling them to go back in case of a faulty choice. The possibility to cancel the unlocking is only available during the connection process. If a problem occurs when connecting to a lock, an error message appears, asking if one wants to make a new attempt. Unlike the other products, the Phoniro Lock does offer a list of possible sources of error to help troubleshoot the problem as shown in Figure 4.12.

A pop-up window appears when one attempts to log out, asking “Are you sure you want to log out?”. The options available are “Cancel” and “Log out”. A pop-up message also appears after pressing the button “Update information” asking “Are you sure you want to synchronize data?”. The options available are “Yes” and “No”. There is no embedded cross in the corner of the pop-up windows, allowing the user to close it easily. The lack of a clearly marked exit to close the window is shown in Figure 4.11.

The shortcut for dialing the care receiver, shown in Figure 4.14, immediately launches a call. A pop-up message does not appear, asking “Are you sure you want to call?” nor is the number pasted into the phone’s dialing screen. This leads to a big risk of the user accidentally making a call by simply pressing the button. Fewer clicks are effective but prone to errors.

11. Low Physical Effort

The number of required clicks is optimized for the application.

12. Size and Space for Approach

Buttons are large and will probably fit everyone.

13. Consistency and Standards

Clickable buttons sometimes have an icon and text, sometimes only icons and sometimes only text. Clickable and unclickable buttons have the same colors and appearance. The feedback indicating that a button is about to be activated, or is activated, differs. Dark blue, grey and orange are used as feedback colors. Sometimes buttons do not change color at all.

The icons used follow platform conventions. The padlock metaphor is used for unlocking/locking of all products and the process does not differ significantly. The meaning of the padlock is however inconsistent since it symbolizes different functions in the different contexts. The meaning of the wrench is similarly inconsistent.

A tap outside of a pop-up window has an inconsistent effect, since it directs the user differently for different pop-ups.

14. Help and Documentation

A manual to help the staff understand how to use the app is available, but lacks a guided tour for novice users in the app. However, the manual has clear headlines and straightforward steps for performance of each action. A tour showing the most important features in the app would have been helpful.

The manual states that one is directed to the “Info” page when choosing a care receiver. However, one is really directed to the sub-tab “Locks”.

4.4 Chosen Product

After completing the product evaluation, a product was chosen for further development. The chosen product was the medicine cabinet, Phoniro Medic Mini. The fact that the product details were not yet figured out, nor implemented in the received product, made the medicine cabinet hard to evaluate but it also entailed great potential for development. Its precursor, Phoniro Medic, was the only evaluated product without added feedback for the locking and unlocking processes. This played a big role in the team choosing the product, since the design of good feedback for the product had great potential of enhancing the user experience.

Since the user experience for Medic Mini is highly correlated to the design of the application, and the communication between the two, some focus would also be laid within this area. The focus for this part would however be on the user-sequence for the unlocking of the medicine cabinet.

4.4.1 Scope

How can the user experience for the medicine cabinet be improved? The overall experience was to be considered but the project’s main focus would be to improve the feedback and discoverability to better communicate the result of an action and

the system status to the user. It was also going to be considered how the intended sequence of action could be clarified.

4.4.2 Delimitations

The focus was to improve the user experience for the interaction process. The current colors and materials in the products were decided to leave unchanged. The added components would be placed where the company had intended them to be, since the cabinet already had existing holes placed out for them there.

5 Identifying Needs

This section covers the identified needs and how they were discovered. It begins by presenting how information from the users was obtained and is followed by data analysis. Furthermore, the needs were extracted from the analysis and personas were created.

5.1 Data Gathering

The three main techniques for data gathering are interviews, questionnaires and observations [5, p. 260]. Since the target group only consisted of the users of Phoniro's medicine cabinet, it was hard to get ahold of many people within the group. Questionnaires are an effective way to collect answers from many users in a short period of time [5, p. 278]. Since the target group solely consisted of the users of Phoniro's medicine cabinet, a relatively small and specific group of people, it was however decided not to use this quantitative data gathering technique. Also, qualitative data were preferred to reach the data gathering goals. Observations with end users were excluded due to the Covid-19 recommendations. Digital interviews were chosen as the method for gathering user opinions at this stage.

5.1.1 Goals of Data Gathering

The goals of the data gathering were to, by interviewing regular users, get insight into their opinions regarding the medicine cabinet and discover problems that they have encountered during repetitive use of the product. Whether the end users inquired for added features were also of interest. The collected data would be used as a foundation for the development of the product. In order to help create personas, the team also wanted to gain insights into the target group's attitudes towards technology and digitization at work.

5.1.2 Interviews

In order to receive answers to specific questions while also allowing personal speculations and opinions, a semi-structured interview format was chosen. Before initiating the real study, a pilot study was conducted to test the questions for clarity. The pilot study can identify potential problems in advance so that the questions can be amended [5, p. 265]. Three persons participated in the pilot study, of which one was the project supervisor. One question was deleted, since it was considered irrelevant, and some questions were rephrased to be more objective.

The contact information to the interviewees were received by contacting digital strategists with help from the company supervisor. The strategists worked in different municipalities in southern Sweden and reached out to their respective staff. The participants were thus not specifically selected by the team because the sample included those who had been selected by the representatives from the municipalities, making it a convenience sampling [5, p. 261]. A total of seven persons were interviewed. Three interviews were conducted individually and two in pairs, since the interviewees' requested that arrangement (see Table 5.1). The interviews were held via videocall with all interviewees but one. Since this person did not have access to a computer or video equipment the interview was conducted over phone.

The interviews were initiated with an introduction of the interviewers and an explanation of the interview goals. To enable transcription afterwards, the interviewees were asked to consent to the session being recorded. A warm-up session with questions about demographic information was followed by the main session with questions about Phoniro's products, mainly focusing on the medicine cabinet. Finally, the interview was rounded off and the interviewees were thanked for their participation [5, p. 276]. The script for the interviews can be seen in Appendix C.

Table 5.1: Demography of the conducted interviews.

<i>Nbr</i>	<i>Gender</i>	<i>Age (yr)</i>	<i>Profession</i>	<i>Experience as assistant nurse (yr)</i>	<i>Experience as installer (yr)</i>
1	Man	26	Installer	-	6
2	Woman	28	Assistant nurse	5	-
3	Woman	51	Installer and assistant nurse	34	10
	Woman	48	Assistant nurse	30	-
4	Woman	39	Assistant nurse	18	-
5	Man	30	Installer	-	5
	Woman	50	Assistant nurse	20	-

5.1.3 Data Analysis of the Interviews

The interviewees included four assistant nurses, two installers and one person who was both an assistant nurse and an installer (see Table 5.1). The interviewees worked in ordinary housing, sheltered housing or housing with special services for adults (LSS). The age of the interviewees varied between 26 and 51 years and there was an even distribution among the ages. How many years the interviewees had worked as assistant nurses varied between 5-34 years and for the installers it varied between 5-10 years. Throughout, the interviewees were rather tech-savvy since several of the assistant nurses were also digital coaches at their workplace.

Two of the seven interviewees had used the Digital Lock Solution from Phoniro throughout their careers while the rest also worked within the profession before the digitalization. Everyone currently used the app when unlocking Phoniro's products, but one interviewee had previously used a tag. The interviewees generally had a positive attitude towards digital key management due to the convenience of getting rid of large keychains, the eliminated risk of losing keys and the improved monitoring of drug management. In the event of an alarm, anyone can go instead of only the person who is currently in possession of the right key. One interviewee however pointed out that it is more time consuming to unlock with the app than with a tag.

Many interviewees pointed out that digital key management contributes to more efficient care and enables more social time with the care receivers. Some of the interviewees did however mention that there are many apps and systems for the staff to learn, and training is sometimes required.

Everyone had used Phoniro's medicine cabinet, Medic, at least once. Some of the interviewees used it only a few times a month but most of them used it several times a day. Most of the interviewees considered it to be quite easy to unlock the cabinet once the procedure was learned. Some persons interviewed mentioned that they had been provided training while some stated that they had learned the process by simply doing it several times. During the interviews, several persons said that the app could communicate more clearly how one should unlock the cabinet. They suggested that this could be done by clearly stating that one must press the button or by demonstrating possible sources of error if the unlocking cannot be completed. One person pointed out that the cabinet is not too complicated to unlock, but neither so easy that one might accidentally unlock it.

Most interviewees stated that one can hear a mechanical sound when the cabinet locks or unlocks itself. Someone mentioned that people with normal hearing probably can hear the sound, but that added feedback could help clarify further, especially for those with impaired hearing. Several interviewees pointed out that they usually try to turn the handle in order to find out whether the cabinet is locked or unlocked. Others mentioned that the "thumbs up" in the app let them know that

the cabinet is unlocked. Some interviewees however conveyed that they had noticed that the cabinet's locking mechanism was unreliable since it did not always lock itself properly. They said that the cabinet is sometimes left unlocked since staff members do not always notice that it has not been properly locked, which suggested that the current feedback for the locking is insufficient.

All interviewees but one were positive towards the implementation of light feedback. They agreed that a green light could signal that the cabinet is unlocked and red that it is locked. Someone mentioned that if a LED was to be implemented, it should only be temporarily lit during the unlocking and locking processes. This was requested since the person thought that a constant shine could disturb the care receivers. One interviewee pointed out that sound feedback might disturb the care receivers, especially those with cognitive impairment.

Several of the interviewees mentioned that the staff would like the inside of the cabinet to light up when it is opened, to make it easier to read the names of the medicines stored inside. They pointed out that the cabinet often is placed where the light is insufficient at daytime and that it is even harder to read the names of the medicines at night when night medicine is to be given. Another feature that was requested was that the staff would be alerted if the medicine cabinet has been unlocked for a long time, mainly in the scenario where the cabinet is not properly locked.

5.2 Needs

Needs were extracted from the data collected in the interviews. First, the needs were organized into four groups; needs related to security, intuitivity, feedback and efficiency. The needs' relative importance was then established, and they were re-sorted into the groups "necessary needs", "wanted needs" and "already implemented or irrelevant for the project".

5.2.1 Necessary Needs

- Medic Mini (MM) communicates to the user how to proceed to unlock.
- MM enables easy interaction for users with bad hearing.
- MM provides pleasant feedback for both users and care receivers.
- MM is intuitive to use.

5.2.2 Wanted Needs

- MM gives an indication of whether the cabinet is unlocked or not.
- MM facilitates the interaction for users with poor night vision.

5.2.3 Needs Already Implemented or Irrelevant for the Project

- MM only allows qualified users to access the medicines.
- MM registers who unlocked and when they did it.
- MM provides reliable unlocking and locking.
- The user can easily replace batteries.
- MM contributes to efficient care.
- MM eliminates the risk of losing keys.
- MM can be opened quickly in case of urgent medication.
- MM allows registration and signing of medication.

5.3 Personas

Personas were created based on the interviewees. One persona, Peter, was however not based on the actual persons interviewed but rather on staff members described by the interviewees. The participants had, as previously mentioned, been selected by representatives from their respective municipalities and all were rather tech-savvy. The interviewees did often describe scenarios where they themselves had little trouble, but where their colleagues had difficulties performing a task. The persona Peter was created to cover this less tech-savvy target group as well.

All personas were created to ensure that the end users were considered when developing the product. Due to Covid-19, the team would not be able to perform user tests involving persons who use the product regularly. To compensate for this, personas representing these users would be considered in addition to user tests with persons without any experience within the area.

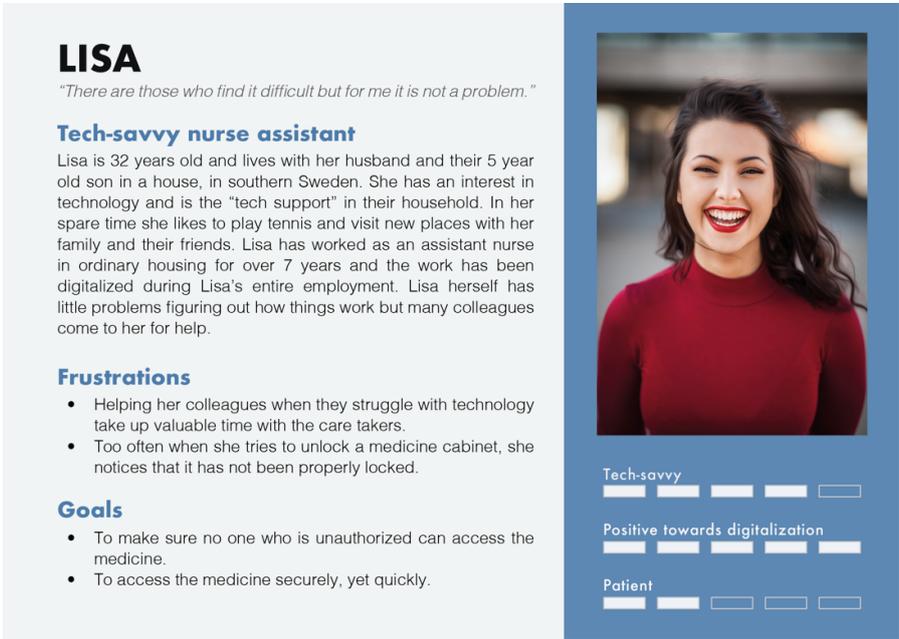


Figure 5.1: The persona Lisa.

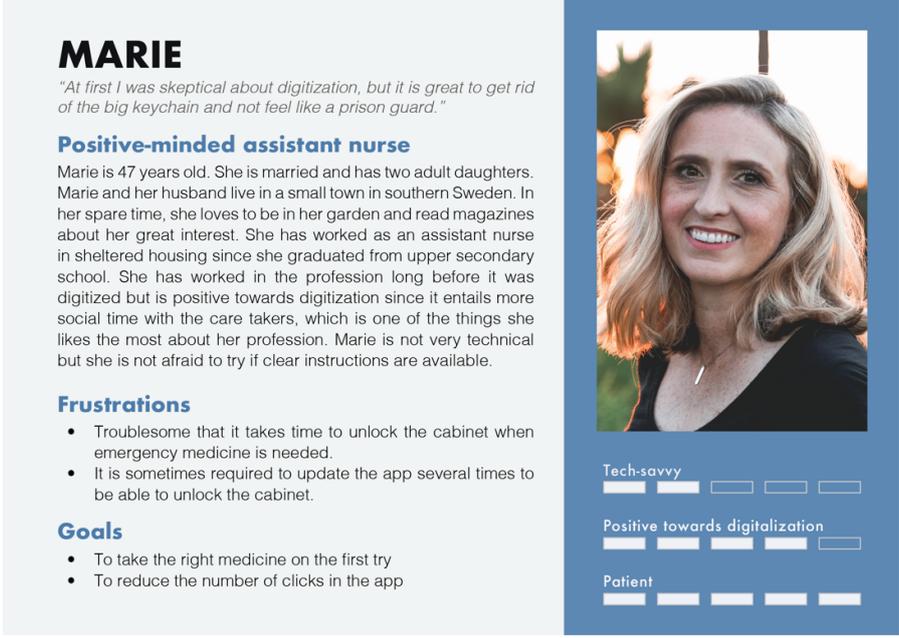


Figure 5.2: The persona Marie.

PETER

"It takes time. It takes time to log in and it takes time to get into the medicine cabinet."

Assistant nurse with technical resistance

Peter is 63 years old and lives alone in an apartment in southern Sweden. He is suffering from hearing loss and is using hearing aid. His passion in life is bowling and he is involved in the local association. When he himself is not playing, he often takes a beer in the bowling bar and watches others play. He has worked in the same special needs housing for the past 30 years. Peter does not keep up with the digitization in the society and does not like that his daily tasks have changed. He is afraid of making mistakes when it comes to technology and usually calls his nephew when he needs help installing digital products at home.

Frustrations

- Always forgets if one has to press the button before pressing unlock in the app or the other way around.
- Troublesome that one is logged out after a while and has to log in again.

Goals

- To access the medicine in the cabinet in a simple way.
- To reduce the number of drug theft.



Figure 5.3: The persona Peter.

6 Concept Generation

This section presents the concept generation. It begins with an external search for existing products and information about different types of feedback. Based on the identified needs, several concepts were created. Also, the selected concept to proceed with is presented.

6.1 Search Externally

Competitive benchmarking and literature studies on LED and audio feedback were done to gather information from external sources.

6.1.1 Competitive Benchmarking

Competitive benchmarking is the process of conducting research on competitor's products. These products can provide ideas and thus make the product under development more competitive and successful [16, pp. 17-18].

There are several different medicine cabinets on the market today. Most of them are made of 2-3 mm steel sheets, which provide secure storage for the medicines. There are also wooden medicine cabinets on the market. These might better blend into the care receiver's home interior but are obviously less secure. There are several different locking systems available for medicine cabinets; mechanical locks, mechanical and electronic code locks as well as radio-frequency identification (RFID) locks that can be opened with a card or tag. Common to most locks are that they can be opened with a master key.

There also exist different types of digital locks that can be mounted on medicine cabinets, e.g., locks from ACSS and Salto. The ACSS lock can be unlocked and locked with RFID and/or code [17]. The feedback is both aural and visual. It lights green and beeps once, both when the cabinet is unlocking and locking. If someone with the wrong access tries to lock or unlock, the LED flashes red and beeps three times. If someone with the right access tries to unlock, but it does not work for some reason, the lock lights red and beeps once [18].

The Salto lock can be unlocked and locked with RFID [19]. When locking, the correct key card is held in front of the lock and a beep sounds simultaneously as the LED flashes green once. It is then possible to turn the knob, and in the end position the same beep is heard, but the LED flashes red instead. When unlocking, one proceeds in the same way, with the distinction that the knob is turned in the opposite direction. The LED lights green before the knob is turned and red when it is turned [20].

6.1.2 LED feedback

Color signals can be used to code information. LED, which is short for light emitting diode, is an efficient and inexpensive way to signal different colors. There are conscious underlying associations to colors [21, pp. 27, 359, 557] and the selection of appropriate color will enhance the communication to the user [22]. Color information is generally processed in an automatic manner [21, p. 27], e.g. in a traffic light where red means stop and green means go [21, p. 178]. Flashing light is a powerful tool to capture attention [21, p. 617].

6.1.3 Audio feedback

Sound design in UX can provide feedback on a user's action or the system status, as well as draw attention to important information such as warnings or opportunities. There is however a limit to how often we can stand hearing the same sound, a repetitive tolerance. For more complex sounds, the threshold falls significantly lower. As a rule of thumb, a sound should be more subtle, shorter and warmer as it is more frequently occurring. [23]

Designers should both look for opportunities where sound can enhance the user experience as well as unnecessary sounds. First, it should be considered what key actions users might want to receive feedback for. It is effective to identify possibilities for sound cues by looking at the user flow. Where can sound *enhance* the user experience? [23]

Integrating sound into the user experience can create a multi-sensory interaction that is very effective. Audio feedback can also be useful for visually impaired people and in the same way, visual feedback might be an important part in ensuring that hearing-impaired users don't miss an essential part of the product.

6.2 Search Internally

Internal search is the process of retrieving personal and team knowledge to generate concepts [16, p. 127]. For each need that emerged during the interviews, ideas and concepts were brainstormed. The internal search started with the two team members working individually, since studies have shown that team members working alone for a period of time will generate more concepts and ideas than when the team works together for the same time period [24]. The individual brainstorming process ended by presenting the individual ideas to each other and compiling them into a common list described below.

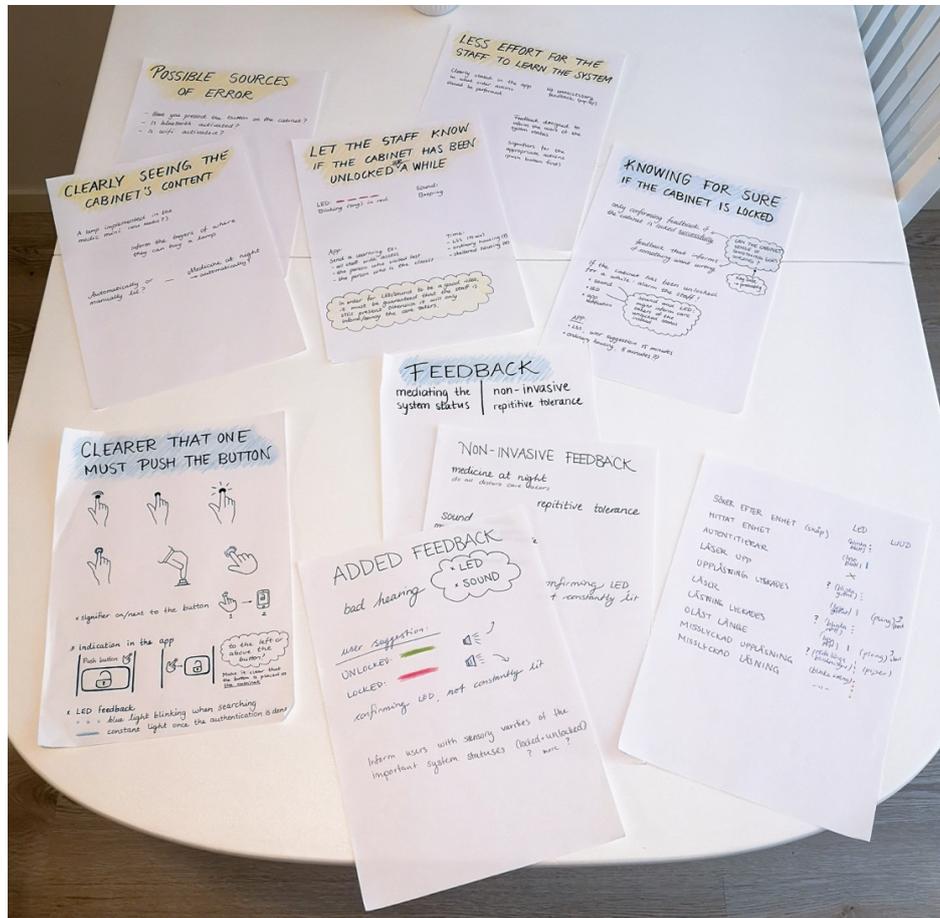


Figure 6.1: The result of an individual brainstorming process

6.2.1 Necessary Needs

MM communicates to the user how to proceed to unlock

To clarify how to unlock the medicine cabinet, it must be better communicated to the user that they must push the button on the cabinet before unlocking in the app. A signifier on, or next to, the button could help clarify this, as well as a more distinct indication in the app. To achieve this, it was suggested to rephrase the prompt “Tryck för att väcka”/”Press to wake” and implement an icon that urges the user to push the button. Whether this icon should be placed to the left of the unlock-button or above it was discussed. Making the icon in a deviating color could help attract more attention to it.

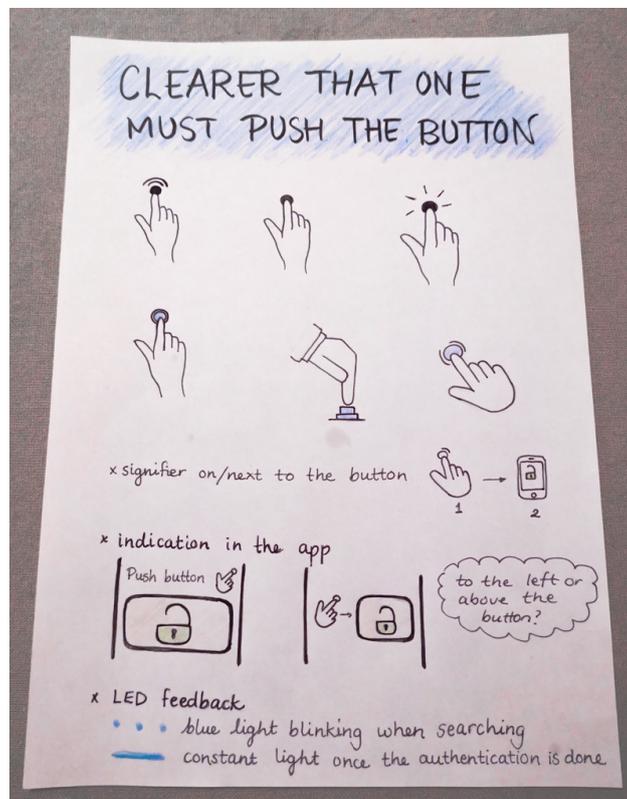


Figure 6.2: Ideas on how to communicate that the cabinet's button must be pushed.

The user should also be reminded by the application to turn on Bluetooth and internet if any of these are off. A pop-up window could also appear if the unlock-button in the app is pressed before the button on the medicine cabinet has been

pushed. A flow chart was made to present the stages of the unlocking and locking process based on the user actions, see Appendix D.

The cabinet should provide feedback when the button is pushed to let the user know that the cabinet is awake and available for interaction. Once the button and the unlock-button in the app have been pressed, the LED light should change to confirm the actions.

MM enables easy interaction for users with bad hearing

Some users might have a hard time hearing the mechanical sound that occurs when the medicine cabinet is successfully unlocked. It was thereby suggested to amplify this feedback by implementing sound feedback. A subtle sound with major tones can be played when the cabinet is unlocked and one with minor tones once it is locked. Additionally, the implementation of LED feedback can facilitate the interaction for users with bad hearing.

MM provides pleasant feedback for both users and care receivers

Sounds should only be implemented when it enhances the user experience, and unnecessary sounds should be avoided. The only system statuses that were considered to require sound feedback were when the cabinet is successfully unlocked or locked. These sounds should be concise rather than excessive since it should be made sure that frequently occurring sounds are short and subtle.

When no one is interacting with the cabinet, and it thereby is in its neutral mode, the LED should be off. This consumes less power and is also less likely to disturb the care receivers. Too intense flashing light should also be avoided since it might be experienced as stressful.

MM is intuitive to use

Once the button on the medicine cabinet and the unlock-button in the app are pressed, the LED should light differently to confirm the actions. Whether the authentication process and the unlocking process should be separated or not is debatable and both variants should be tried.

To mediate that the medicine cabinet is awake and available for interaction, the LED could start flashing when the button has been pushed. It should keep flashing until the unlock-button in the app has been pressed or until the cabinet goes back to sleep.

The messages in the app should show what the LED light means. It can be made clearer that one can interrupt the unlocking process during the authentication by making the clickable word “Avbryt”/“Cancel” look more like a button. According

to the interviewees' suggestions, the LED can light green when the cabinet is unlocked, and red when it is locked.

6.2.2 Wanted Needs

MM gives an indication of whether the cabinet is unlocked or not

Another color and sound feedback can be given if the cabinet is not unlocked or locked properly. As seen in Figure 6.3, a proposal was to signal this with a flashing orange light and a sound.

SYSTEM STATUSES	FEEDBACK
Sleeping	
Searching	Blue bars
Authenticating	Blue bar
Unlocking	Green bars
Unlocked	Green bar and speaker icon
Locking	Red bars
Locked	Red bar and speaker icon
Failed to unlock	Orange bars and speaker icon
Failed to lock	Orange bars and speaker icon
Unlocked for a while	Red bars and speaker icon

Figure 6.3: The different system statuses and ideas of corresponding feedback.

MM facilitates the interaction for users with poor night vision

To make it easier to quickly find the wanted medicine in the cabinet, a light can be integrated inside the cabinet. If the light is automatically turned on when the door is opened, the interaction will be eased primarily for users with poor night vision, but it will likely ease the search for all users.

6.3 Final Concept

6.3.1 Application

It was decided to update the unlocking page in the app in order to clarify how to proceed to unlock the cabinet. Changes that would be done was to rephrase the prompt “Press to wake” in the app and then place an icon, that mediates that the button must be pushed, to the left of the unlock-button. If the user pressed the unlock-button in the app before pushing the button on the cabinet, a pop-window would appear prompting the user to push the button on the medicine cabinet.

The messages in the app will mediate the system statuses and the meaning of the LED light, but the number of messages was decreased since they passed by so quickly in the original application. To make it clearer that one can interrupt the unlocking process, the clickable word “Cancel” was made more button-like.

6.3.2 Feedback

When the cabinet was sleeping, due to the lack of interaction, the RGB LED would always be off. Once the button had been pushed, the LED would start flashing blue. The blue color was chosen since the cabinet and the app are communicating via Bluetooth. It was decided that the LED would continue flashing until the unlock-button had been tapped in the app, or for a maximum of 10 seconds if no further action was taken and the cabinet went back to sleep.

Once both the button on the medicine cabinet and the unlock-button in the app had been pressed, the LED would exceed to a constant light to confirm the actions. It was discussed whether the LED should provide the same feedback for both the authentication and unlocking processes or if these processes should be separated, like in the Key Safe. It was decided to try both variants in the upcoming user tests.

For the unlocking process, a flashing light felt like the best option, but it was decided to try a constant light as well. In accordance with the interviewees’ suggestions, the LED would light green when the cabinet was unlocked, and red when it was locked. The green light would go out when the cabinet was opened, and the red light after a few seconds delay.

It was decided to try the implementation of a sound with major tones when the cabinet was unlocked and one with minor tones when it was locked. The sound would be made short and subtle in order not to be disturbing when played many times.

6.3.3 Additional Features

It was decided to implement a lamp inside the cabinet that would light up once the cabinet was opened. It was also chosen that the cabinet would lock itself after a while if it had not been opened.

7 Prototyping and User Tests

This section covers the prototypes and how the tests were performed. It begins by presenting how the prototypes were created and the framework of the user tests. This is followed by presenting each iteration and its tests results.

7.1 Hardware

Permission was given to use the cabinet received from Phoniro in prototyping. There were no restrictions regarding what could be done with it and in order to carry out convincing user tests, the team decided to build an electronic system including Arduino. To make it easier for the users to properly open the cabinet, a doorknob was produced. It was created in CREO Parametric and printed using fused filament fabrication (FFF) in Certec's lab at IKDC. The same method was used to create holders for electronic components in the prototype, see Figure 7.1.



Figure 7.1 : The 3D printed parts in the prototype.

Since it is easy to configure vary the feedback by simply editing the code when using Arduino, it was decided to skip the lo-fi stage and create a hi-fi prototype immediately. Instead of doing lo-fi tests, several iterations of tests were performed on the hi-fi prototype. The variants of feedback were successively developed and refined after each test round, to get more relevant feedback options.

7.1.1 Electronics

The electronic components needed for the prototype were an RGB LED, a LED strip, a speaker, buttons and a micro switch. To build a working system, an Arduino UNO board, cables and resistors were needed.

The RGB LED and the speaker were used to mediate feedback during the unlocking and locking processes. The LED strip was used to try the effect of integrated light in the ceiling of the cabinet. The micro switch was used to sense whether the door was closed or not, which in turn controlled the LED strip, the RGB LED and the speaker. The button seen in Figure 7.1 was already integrated into the cabinet. This button was programmed to initiate the simulated unlocking process, and thereby controlled the RGB LED feedback. Another button, seen on the bread board in Figure 7.2, was used to simulate a click on the unlock-button in the app.

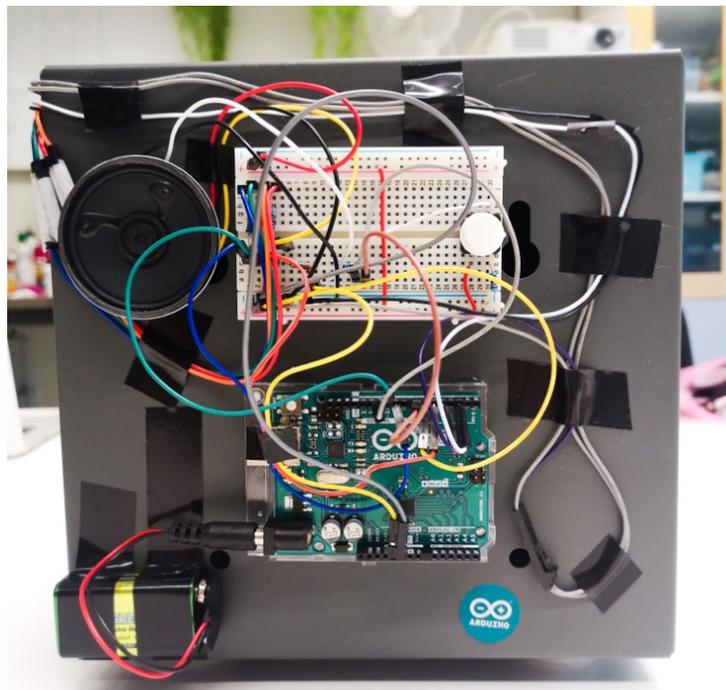


Figure 7.2: The implemented electronics in the final prototype.

7.2 Software

7.2.1 Arduino

The software Arduino IDE was used to write the code and upload it to the Arduino UNO board. The programming language is called Arduino Programming Language (APL) and is similar to the C++ languages. The sketch, as the Arduino program is called, has a *setup* and a *loop* function. The *setup* function only runs once after each powerup or reset of the board. The *loop* function is used to actively control the Arduino board and loops consecutively [25]. The code used in the prototype can be seen in Appendix E.

7.2.2 Figma

The software tool Figma enables display on mobile devices and was used to create a working prototype of the application. Print screens from Phoniro's application, Home Care, were used in the prototype. Since the project's focus mainly was to improve feedback on the medicine cabinet, the appearance of the prototype was similar to the actual app that was evaluated in section 4.3.5 Phoniro Home Care App. However, some changes were done to improve the user experience and ease the user flow during the tests, see Figure 7.8a-b.

7.3 User Tests

7.3.1 Test goal

Since little information could be found on how to ideally design light feedback, it was decided to do several iterations of user tests to investigate how users perceive different variants of LED feedback. The focus was to investigate when constant versus flashing light should be used and what colors were ideal for representation of the different system statuses in the medicine cabinet's unlocking process. The implementation of audio feedback was also evaluated in the tests. It was also examined how the different types of feedback are perceived during nighttime, and whether the implementation of integrated light has a big impact on the overall experience.

7.3.2 Test setup

All user tests were initiated with an introduction of the product and an explanation of the test goal. The test persons were asked to keep an eye on the feedback on the medicine cabinet and not solely focus on the app when unlocking in the test. To enable transcription afterwards, the users were asked to consent to the session being recorded. The prototype was presented and the product's area of use, as well as its end users, were explained. It was emphasized that the test was mainly performed to see how different kinds of feedback are perceived and that there were no right or wrong answers, only personal opinions. Before the test began, the participants were encouraged to think aloud. In this way, the thought process becomes externalized, and a greater understanding can be gained of the user's thought process [5, p. 296].

Before the interaction with the cabinet was initiated, the users were asked to state their age and answer a few questions about associations they had with different colors. Afterwards, they were given instructions regarding how to proceed with the interacting part of the test. During the interaction, the test leaders asked questions that followed a framework that was the same for all tests, only with small updates after some of the iterations. The final form can be seen in Appendix E. While the users interacted with the medicine cabinet, they were observed by the team. The observations helped the team understand how well the prototype supported the tasks [5, p. 287].

The test setup was slightly modified for each iteration. Common to all setups was that the user interacted with the medicine cabinet and tried variants of LED combinations. The order of the variants was varied for the different users to prevent this from affecting the test results. The users were given login details and were asked to unlock the medicine cabinet via the prototype of the application, see Figure 7.3. They remained logged in during the entire test but unlocked the cabinet every time they tried a new feedback variant. The LED feedback that the user considered to be clearest was also tested in a dark room to simulate nighttime and try the integrated light. They were asked to fetch a specific medicine from the cabinet and bring it to the fictive care receiver Asbjörn Testsson, represented by a stuffed bear (see Figure 7.3). For more detailed descriptions, see 7.4.1 First Round of User Tests, 7.5.1 Second Round of User Tests and 7.6.1 Third Round of User Tests.

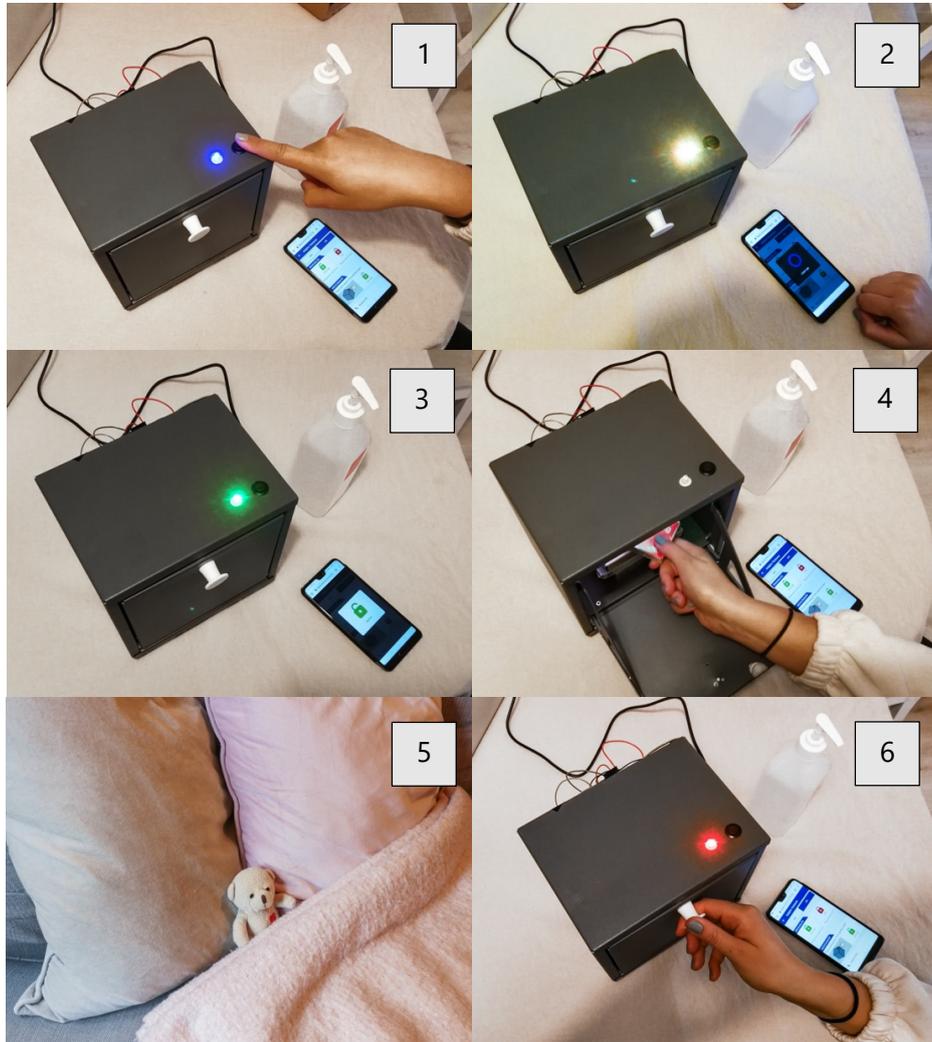


Figure 7.3: The different stages in the process of unlocking the cabinet, giving the care receiver medicine and closing/locking the cabinet, which was done by the users in the tests.

When the test person pushed the unlock-button in the prototype app, one of the test leaders pushed a button on the back of the cabinet (see Figure 7.2) to solve the problem that arose as the app prototype could not communicate with the cabinet prototype. But by having one of the test leaders push a button simultaneously as the user pushed “Unlock” in the app, the app appeared to communicate with the cabinet to the user.

Due to Covid-19, the team was not able to perform user tests on the real end users. Instead, user tests were performed on people in the team's social circles. However, some of the test persons had experience in healthcare, but only a few had experience from working in care receivers' home environment.

7.4 First Iteration

The components in the first iteration of the prototype were an RGB LED, a LED strip, two buttons and a micro switch. The RGB LED started flashing when the button on the medicine cabinet was pushed and continued to do so until the unlock-button in the app had been pressed. A pop-up window appeared in the app when the user pressed the unlock-button, asking if the button on the medicine cabinet had been pushed (see Figure 7.4). The pop-up appeared regardless of whether the button recently had been pushed or not since the prototype app and the cabinet could not communicate.

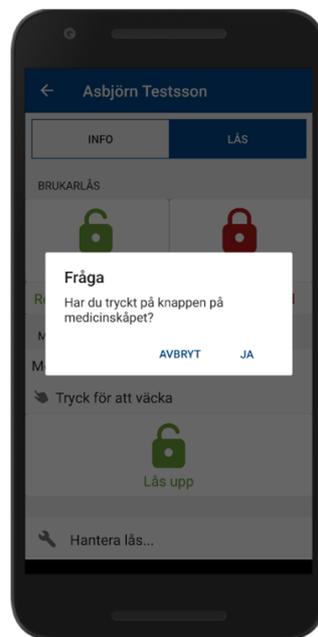


Figure 7.4: The pop-up message that appeared when the unlock-button was pressed.

Three variants of LED feedback were tested in the first iteration, see Figure 7.6. In all variants, the LED started flashing blue once the button on the medicine cabinet was pushed. The frequency of the blue flashing light was 1,3 Hz and it flashed for a

maximum of 10 seconds if no further action was taken. When the unlock-button in the app had also been pressed, the LED changed to a constant blue light to indicate that the cabinet was authenticating. The authentication lasted in 3 seconds and a loading wheel appeared in the app as well as a message mediating the system status. During the authentication, it was possible to interrupt the process, and the cancel-button was clarified by giving it the same appearance as several other buttons in the app (see Figure 7.5). The authentication process is followed by the unlocking process which was announced in the app and with three different variants of LED colors for the different feedback versions. The unlocking lasted for 3 seconds, and the frequency of the flashing light was 0,9 Hz.

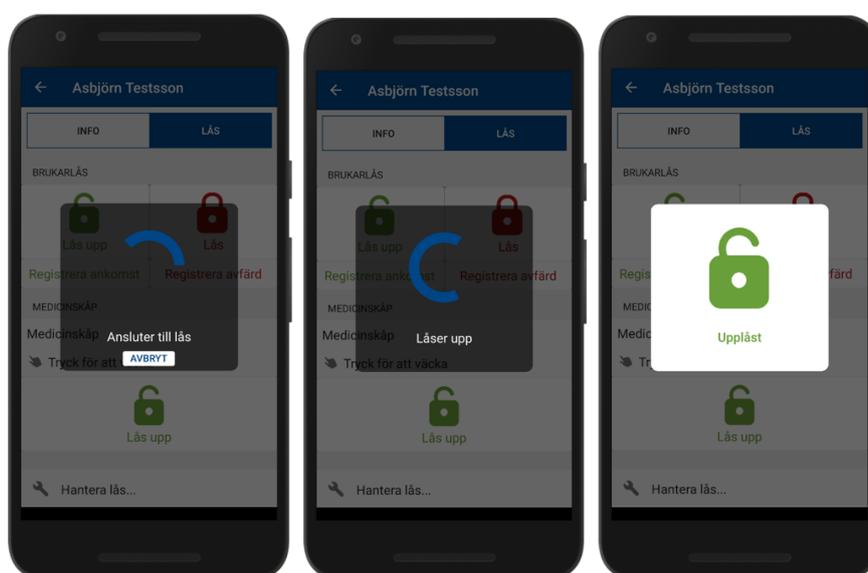


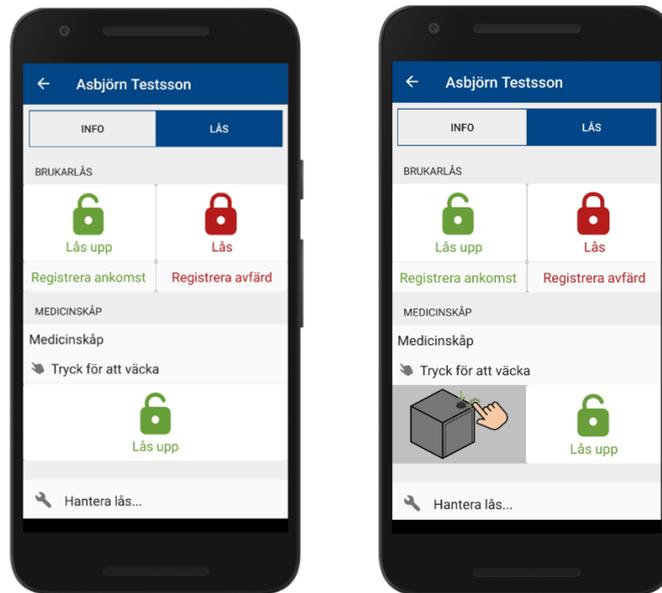
Figure 7.5: The messages displayed on the screen during the unlocking process. The number of messages was reduced from the original app.

Once the medicine cabinet was unlocked, this was announced in the app and the LED lit green. The green light went out once the cabinet was opened and the LED strip inside the cabinet lit up simultaneously. It stayed lit until the cabinet was closed and the RGB LED lit red to indicate that the cabinet had been locked. The version that flashed green during the unlocking process also flashed red during the locking process (1.3 in Figure 7.6) with the same frequency as for the unlocking.

It was suggested in the concept generation to rephrase the prompt “Tryck för att väcka”/”Press to wake” in the app and implement an icon that urges the user to push the button. It was decided to test the original page with users before implementing the new one. However, the page with the new icon (see Figure 7.7b) was shown to receive feedback from the test persons.

SYSTEM STATUS	LED FEEDBACK			USER ACTION
	1.1	1.2	1.3	
Sleeping				Push the button
Awake/waiting	▬▬▬	▬▬▬	▬▬▬	Unlock via app
Authenticating	▬	▬	▬	Wait
Unlocking	▬	▬▬▬	▬▬▬	Wait
Unlocked	▬	▬	▬	Open
Locking			▬▬▬	Wait
Locked	▬	▬	▬	OK to leave

Figure 7.6: The LED variants in the first iteration.



a) The original page

b) The re-designed page that was shown

Figure 7.7a-b: The original and re-designed page for the locks belonging to Asbjörn Testsson for the first iteration.

7.4.1 First Round of User Tests

The test began by asking the user what their associations are in general but also in technical contexts with the colors green, blue, red and white. Then they paired one or more colors they associated with an error message, success, unlock, lock, connect and loading.

The user interacted with the medicine cabinet and tried the variants of LED combinations. The user was asked to choose which variant of LED feedback they considered to be the clearest and answered questions about how they interpreted the different LED colors as well as how they perceived the meaning of a flashing versus constantly shining LED light. The final part of the test was for the user to try the integrated light during simulated nighttime. Since the tests were performed during the day, in a room where the blinds did not properly block the sun, the simulated nighttime was however not nearly as dark as desired.

7.4.2 Analysis of the First Round of User Tests

Three persons of mixed ages participated in the first round of user tests (see Table 7.1). One problem that became evident during these tests was that the test persons attempted to unlock the lock at the top of the page (“Brukarlås”, see Figure 7.8a) instead of the one controlling the medicine cabinet. The clickable surfaces for different buttons were also noticed to be too little since it was discovered on several occasions that the push of a button was not detected by the app prototype.

Table 7.1: Users in the first test round.

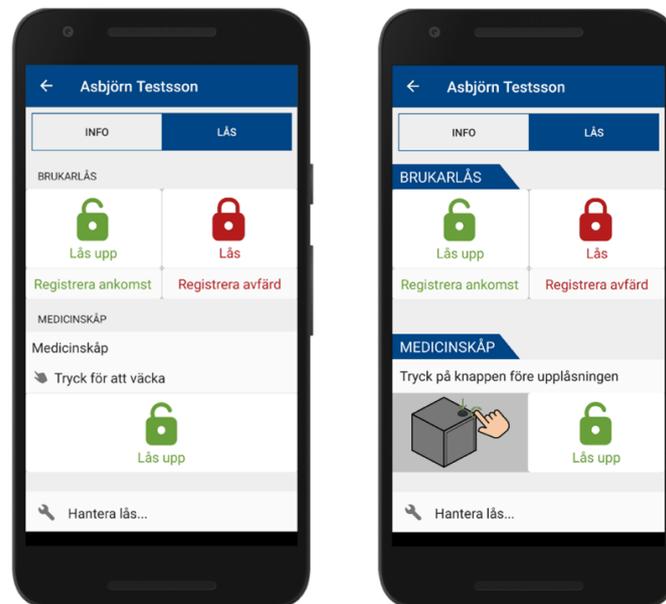
<i>Nbr</i>	<i>Gender</i>	<i>Age range (yr)</i>	<i>Experience in healthcare</i>	<i>Clearest variant of LED feedback</i>
<i>1.1</i>	Man	56–70	Yes	1.3
<i>1.2</i>	Woman	≤ 25	No	1.2
<i>1.3</i>	Woman	41–55	Yes	1.2

“Tryck för att väcka”/“Press to wake” was not distinct enough according to the test persons who were asked. The icon for pressing the button in see Figure 7.8a was perceived as if one was supposed to tap on the phone according to a couple of users. One thought that maybe, by tapping the message area on the screen, the care receiver was woken up during nighttime. It was also noted that the pop-up window, asking the user whether they had pushed the button or not, was useful during the first test since none of the users pushed the button before trying to unlock. However, when the unlocking process had been performed once and the test person knew how to proceed, the pop-up window was a disturbing addition.

All three test persons expressed that they would have preferred if the color for the waiting process was yellow, due to the traffic light metaphor. All test persons also agreed that a flashing light mediated that the process was loading, and that one was supposed to wait. Once the light switched to being constant, the users interpreted that the loading was finished and that one should act. However, in the version where the loading was mediated by a flashing green light, one of the test persons opened the cabinet immediately as the LED started to flash green. Afterwards, they understood that they should have waited but said that the reaction to the green color was stronger than the one to the flashing: “color dominated”, they said.

7.5 Second Iteration

Since the clickable surfaces for different buttons had been noticed to be too small, and thereby disturbed the user flow in the first round of user tests, the touchable surfaces were enlarged. In an attempt to clarify which lock was related to the medicine cabinet, the headers were updated to attract more attention, see Figure 7.8b.



a) The original page

b) The updated page

Figure 7.8a-b: The original and updated page for the locks belonging to Asbjörn Testsson for the second iteration.

The pop-up window asking the user whether they had pushed the button or not was considered to be disturbing in the first round of tests and was thereby removed in the second iteration. It was decided to try to clarify the process without the use of a pop-up. The message informing the users that they must press the button in order to enable the unlocking was updated since “Tryck för att väcka”/“Press to wake” was not distinct enough. The text and the icon were replaced by a picture of the entire cabinet combined with a tapping finger on the *button on the cabinet*. The text was also changed to “Tryck på knappen före upplåsningen”/“Press the button before unlocking” (see Figure 7.8a-b).

The various LED feedbacks were updated as well, but the frequency of the flashing lights for the connection process and loading process were not changed. The duration of the different processes were also kept unmodified. The feedback for the locking was changed to only include a constant red light once the cabinet was closed since it was assumed that the locking would be instant, like in the Key Safe. Since all the three test persons in the first test round expressed that they would have liked it if the color for the waiting process was yellow, this was implemented in one of the updated LED feedback versions, replacing the white flashing light. The blue light during the authentication was also replaced by a flashing yellow light in the same version (2.2), making this the feedback for the entire waiting process. The flashing green light (2.3) was kept as an option to investigate whether the opinion that color overrules flashing/constant light was the same among users in the future tests too. The LED variant that lit blue during the authentication and unlocking (1.1 in Figure 7.6) was replaced by the same feedback as in the Key Safe (2.1 in Figure 7.9). All LED variants in the second iteration are shown in Figure 7.9.

SYSTEM STATUS	LED FEEDBACK			USER ACTION
	2.1	2.2	2.3	
Sleeping				Push the button
Awake/waiting	☰	☰	☰	Unlock via app
Authenticating	■	▯▯▯▯▯	■	Wait
Unlocking		▯▯▯▯▯	▯▯▯	Wait
Unlocked	■	■	■	Open
Locking				Wait
Locked	■	■	■	OK to leave

Figure 7.9: The LED variants in the second iteration.

The speaker was also added in the second iteration. This made it possible to hear a short subtle sound when the cabinet was unlocked and locked. It was decided to implement sound in all versions of code and disconnect it when only LED feedback was wanted.

7.5.1 Second Round of User Tests

Before the second round of tests, the form of questions was rewritten. Some of the questions were excluded, since they gave too little important information, were unclear or simply redundant. However, the user test started in the same way as in the first round of user tests with questions about associations to different colors.

The test person tried the variants of LED without the speaker connected. After each LED variant, questions were asked about how the different colors were interpreted by the test person and after each new alternative that was shown, the test person compared it with the previous ones. When all LED versions had been shown, the speaker was connected, and sound was added to the LED variant that the test person preferred. Questions were asked about the sound and whether the test person preferred both sound and light feedback or only one of them, and what they considered to be clearest.

The second test round also ended with the user unlocking the medicine cabinet in a dark room, to simulate nighttime. The test person was asked about how they

experienced the sound and light feedback at night and whether they preferred both sound and light feedback or only one of them. The test person was asked to find a specific medicine in the cabinet with the integrated light both on and off. They then answered questions about how they experienced the different scenarios.

7.5.2 Analysis of the Second Round of User Tests

Two persons in different age ranges participated in the second round of user tests. Both had experience in healthcare and one of them had experience in using Medic Mini’s precursor, Phoniro Medic (see Table 7.2). She was an experienced user of Phoniro’s products since she uses them in her daily work. She pushed the button on the medicine cabinet and unlocked the correct lock immediately, while the other person attempted to unlock the lock at the top of the page. After a while, she realized that she was trying to unlock the care receiver’s front door (“Brukarlås”/“Client lock”) and immediately pushed the unlock-button. She unknowingly ignored the instructions shown in the message and picture. Since the pop-up window reminding the user to push the button on the medicine cabinet was deleted, she did not understand that it was incorrect, and the test was interrupted. After the test leader asked the test person to look at the picture and read the instructions she understood how to proceed.

Table 7.2: Users in the second test round.

<i>Nbr</i>	<i>Gender</i>	<i>Age range (yr)</i>	<i>Experience in healthcare</i>	<i>Clearest variant of LED feedback</i>
2.1	Woman	26–40	Yes. Have used Phoniro Medic.	2.1
2.2	Woman	56–70	Yes	2.2

The distinction between the authentication and the unlocking processed seemed to be unnecessary but was kept as an option for future tests. The users considered it to be clearer when the same type of LED feedback was shown during both the authentication and the unlocking. They argued that most users will see it as one process and that different types of feedback are therefore unnecessary and confusing. The user that preferred the same feedback as the in key safe wanted the LED to light blue until it was unlocked.

One of the test persons suggested that, when the button of the medicine cabinet was pushed, the LED could light blue instead of flash. Both thought it was great that the red light confirmed that the cabinet was locked. They also liked the sounds that were played when the cabinet was unlocked and locked. They did not think the sound would be disturbing since the care receiver has to be waken regardless in order to be given medicine. There is no reason to unlock the cabinet in the middle of the night if not medicine is to be given.

7.6 Third Iteration

Since the users in the second test round liked the sound feedback that had been played as the cabinet was unlocked and locked, it was kept unmodified in the third iteration. One test person suggested that a constant blue shine could be implemented when the button on the medicine cabinet had been pushed, instead of the flashing blue light. The LED variants in the second round of tests were kept but a fourth version was also added with this feature implemented (3.4). All versions can be seen in Figure 7.10.

SYSTEM STATUS	LED FEEDBACK				USER ACTION
	3.1	3.2	3.3	3.4	
Sleeping					Push the button
Awake/waiting	≡≡≡	≡≡≡	≡≡≡	■	Unlock via app
Authenticating	■	≡≡≡≡≡	■	≡≡≡≡≡	Wait
Unlocking		≡≡≡≡≡	≡≡≡	≡≡≡	Wait
Unlocked	■	■	■	■	Open
Locking					Wait
Locked	■	■	■	■	OK to leave

Figure 7.10: The LED variants in the third iteration.

7.6.1 Third Round of User Tests

In the third round of user tests, most of the questions in the form were kept unchanged. The question about what associations the user had to the colors green, blue, red and white was the only one removed. Due to the open formulation of this question, the users were uncertain what to answer and the responses varied more than desired. The question regarding associations to colors and specific system statuses was considered to provide sufficient information.

In the third round of tests, the team made sure to inform the users that they entered the home of the care receiver Asbjörn by unlocking the front door with the app. This was because it was noted that one user tried to unlock the front door despite the headings being made clearer.

7.6.2 Analysis of the Third Round of User Tests

Eight persons participated in the third round of user tests. Most of them were 25 years old or younger, with a few exceptions. None of them had any experience in working within healthcare (see Table 7.3).

Some of the test persons tried to unlock the front door even though it was explained that they had already entered the care receiver's home. They thought the word "Brukarlås"/"Client Lock" was unclear since the word "Brukare"/"Client" was unknown to them. They suggested that the heading could be phrased "Ytterdörr"/"Front door" instead, to clearly inform the user what kind of lock it unlocked.

Table 7.3: Users in the third test round.

<i>Nbr</i>	<i>Gender</i>	<i>Age range (yr)</i>	<i>Experience in healthcare</i>	<i>Clearest variant of LED feedback</i>
3.1	Woman	≤ 25	No	3.2
3.2	Woman	≤ 25	No	3.2
3.3	Man	26–40	No	3.4
3.4	Woman	41–55	No	3.2
3.5	Woman	≤ 25	No	3.2
3.6	Woman	26–40	No	3.2
3.7	Man	≤ 25	No	3.1 or 3.2
3.8	Woman	≤ 25	No	3.4

Several persons pressed the unlock-button before pushing the button on the cabinet. Since the pop-up window reminding the user to push the button had been removed, the test had to be interrupted by the test leaders when this happened. The test persons got confused and did not understand why the test was interrupted until the leader asked them to read the instructions in the app. Some of the test persons stated that they had not seen, or read, the instructions the first time. They immediately pressed the unlock-button since it was big and green, and thereby attracted their attention. One thought the icon only was a picture of the cabinet to make it easy to find the cabinet in the app. Another person reacted to the fact that some attributes on the cabinet were missing on the icon, for example the button and the LED.

It was discussed with the test persons how the unlocking could be clarified. Some suggested that the instructions could be written in two steps to clarify the procedure and one person suggested that a short instructional video could be shown the first time the app was used.

Most of the users considered it to be unclear when the LED feedback changed during the waiting period. They said that the change of color was probably related the cabinet's unlocking process but argued that different types of feedback for the

different stages were unnecessary since the user do not need to know exactly *why* they are waiting but only that they must wait. It was considered clearer if the entire unlocking process had one color. One person also pointed out that they preferred when different colors were used to symbolize for different parts of the process. They considered it confusing when the same color has different meanings depending on if it lights constantly or flashes.

The unlocking and locking sounds were appreciated by the test persons. They noticed the upward tones for the unlocking and the downward ones for the locking. “It’s short but still informative” one said. It was also appreciated that the light and audio feedback confirmed that the cabinet is unlocked or locked.

All test persons preferred the cabinet with the integrated light, since it eased the search of specific medicines. Some persons turned on their cell phone’s flashlight to be able to see inside the cabinet when the integrated light was disconnected, while some used the phone’s screen light. One of the users suggested that a light sensor could be implemented to turn on the light when the surrounding light was insufficient.

When the test persons performed the test in a dark room, during simulated nighttime, some perceived the LED feedback to be dazzling. One also suggested that the volume of the sound feedback could be either adjustable or set at a lower volume at night.

One test person had two favorite variants of LED feedback, 3.1 and 3.2. This person mostly viewed the app when they unlocked the cabinet, and thereby said that they did not think that the design of the LED feedback was that important, since the app mediated what was going on. However, they said that it would have been better if the light did not go out during the unlocking process in 3.1 and suggested that the LED could proceed to light blue until the cabinet was unlocked.

Some of the test persons left the medicine cabinet open when they gave the care receiver medicine, while others closed it. Most of the test persons had difficulties closing the cabinet once they had retrieved the medicines, since the arms on the sides made it is impossible to close the cabinet if items had been placed along the edges. Many users had a hard time understanding why cabinet could not be closed, and the test leaders had to intervene at a few instances.

8 Compilation of Test Results

This section presents the statistics and results from the three iterations of user tests.

A total of 13 persons of mixed ages participated in the three rounds of user tests. Due to the corona pandemic, the tests were performed on persons in the team's social circles and not on real end users. However, some of the test persons had experience in healthcare, even though most of them did not.

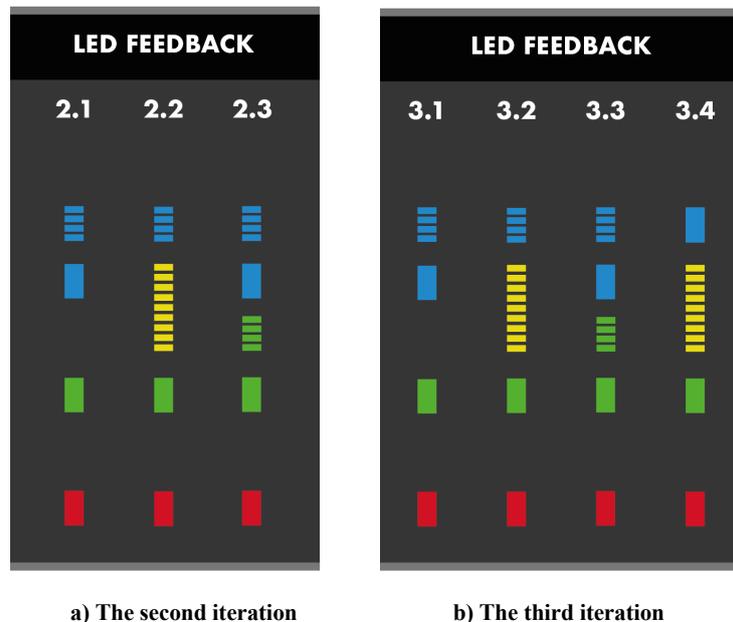


Figure 8.1a-b: The LED feedback used in the second and third iteration. 2.1 equals 3.1, 2.2 equals 3.2 and so on. 3.4 was added in the third iteration and had no equivalent in the second iteration.

Clearest variant of LED feedback

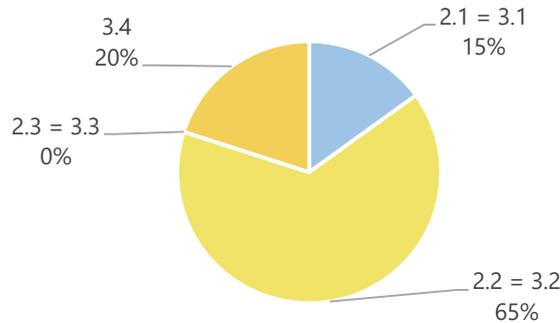


Figure 8.2: Diagram of what the users in the second and third round of tests considered to be the clearest LED feedback.

Most of the test persons in the second and third round of test considered feedback 3.2 (=2.2) to be the clearest, see Figure 8.2. The variant that received second most votes was 3.4, which was very similar to 3.2 but with the difference that it lit blue constantly instead of flashing when the user pushed the button on the medicine cabinet. Figure 8.2 shows that 85 % considered yellow to be a good color to mediate that the user was supposed to wait. Yellow light was not implemented in the first round of tests, but it was stated by all users in that round that this color would have been preferred, due to the traffic light metaphor. If the test persons suggestion about the yellow color in the first test round counts as if this LED variant was the one they considered to be the clearest, even though it was not technically an option at the time, it results in 88 % preferring this option (see Figure 8.3).

Those who considered 3.4 to be the clearest variant had a stronger belief that constantly lit light is mediating that the system is waiting for the user's response, while flashing light means that the system is currently working. Most who considered 3.2 to be the clearest variant agreed that flashing light means that no response is required from the user, but that constantly lit light means that a process is complete. This made them prefer flashing light when the process was initiated.

The LED feedback that flashed green during the unlocking (3.3) was kept in all iterations to investigate whether color overrules flashing/constant light. Some mentioned that it takes a second before one noticed that the light is flashing and not constantly lit. A few test persons acted quickly and did not detect the flashing light. They did neither notice that the process was still ongoing in the app and opened the cabinet immediately when the LED lighted green.

What color the test persons preferred during the unlocking process

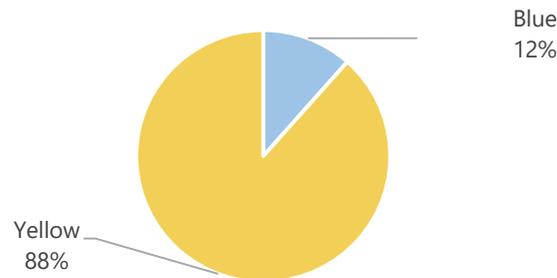


Figure 8.3: Diagram of what the users in all iterations considered to be clearest during the unlocking process.

According to the answers from the initial questions about what color the test persons associated with different system statuses, the majority associated loading with the color yellow (see Figure 8.4). All test persons associated unlocked and succeeded to the color green. Several associated locked with red, but other colors were also mentioned. Many also associated an error message to the color red, but yellow and orange were also mentioned. Some argued that it depends on the severeness of the error, where red is very serious, and yellow is less serious. It was the most even between the colors associated to connecting, but the majority chose the color blue.

Associating colors

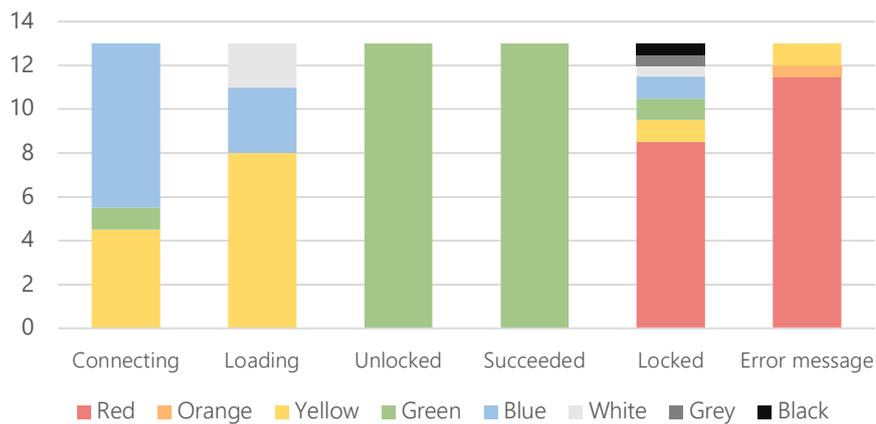


Figure 8.4: Diagram of what the test person associated with a specific color.

Before the second iteration, audio feedback was not implemented. When it was implemented, the test persons were asked whether they preferred both sound and light feedback or only one of them, as well as what they considered to be clearest. The vast majority preferred both LED and sound feedback, see Figure 8.5. They agreed that the sound feedback enables time. All test persons but preferred the same feedback they thought was the clearest

What feedback did the test persons prefer?

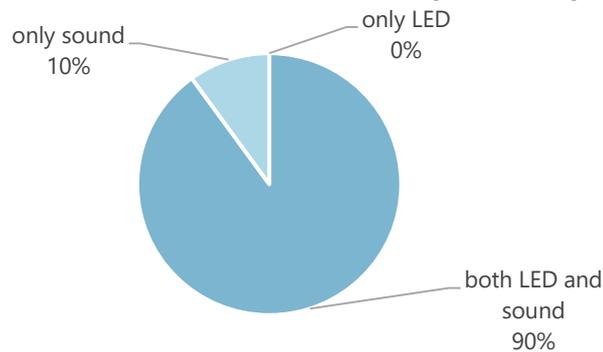


Figure 8.5: Diagram of what type of feedback the test persons preferred.

All test persons did appreciate the integrated light and argued that it made it easier to see inside the cabinet. It contributed to them being able to find a specific medicine faster, which makes the process more efficient. It is also a safer since it minimizes the risk of the person retrieving the wrong medicine. When the integrated light was disconnected, some persons turned on the cell phones' flashlight to see inside the cabinet. The flashlight shined unnecessarily bright and it was cumbersome to have to perform additional steps to complete the task.

9 Final Proposition and Evaluation

This section presents the final design proposition as well as an evaluation of it. Also, an evaluation of the different unlocking pages used in the test rounds is presented.

9.1 Final Proposition

Since the majority of the test persons in the second and third rounds of tests considered the feedback 2.2 (=3.2) to be clearest, this was chosen for the final proposition, seen below.

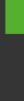
SYSTEM STATUS	FEEDBACK	USER ACTION
Sleeping		Push the button
Awake/waiting		Unlock via app
Authenticating		Wait
Unlocking		Wait
Unlocked		Open
Locking		Wait
Locked		OK to leave

Figure 9.1: The feedback in the final proposition.

In the third round of user tests, it was suggested that the locking page could be re-design so the instructions were listed as two steps, to further clarify the unlocking process. Question marks next to the headings were added to make additional instructions available. The knob was also added on the icon of the cabinet to make it look more like the actual cabinet. The updated page and the pop-up that appeared when the question mark was pressed is shown in Figure 9.2a-b.

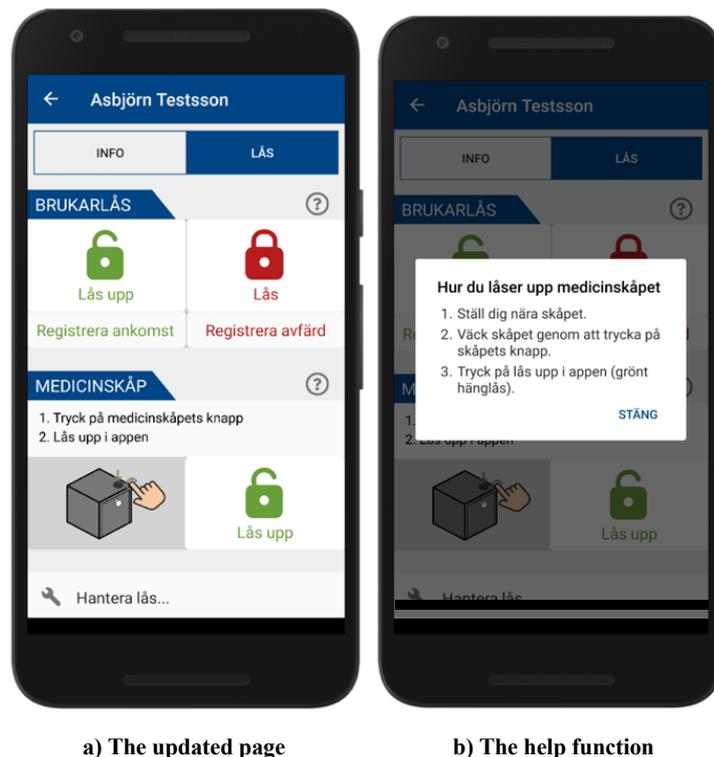
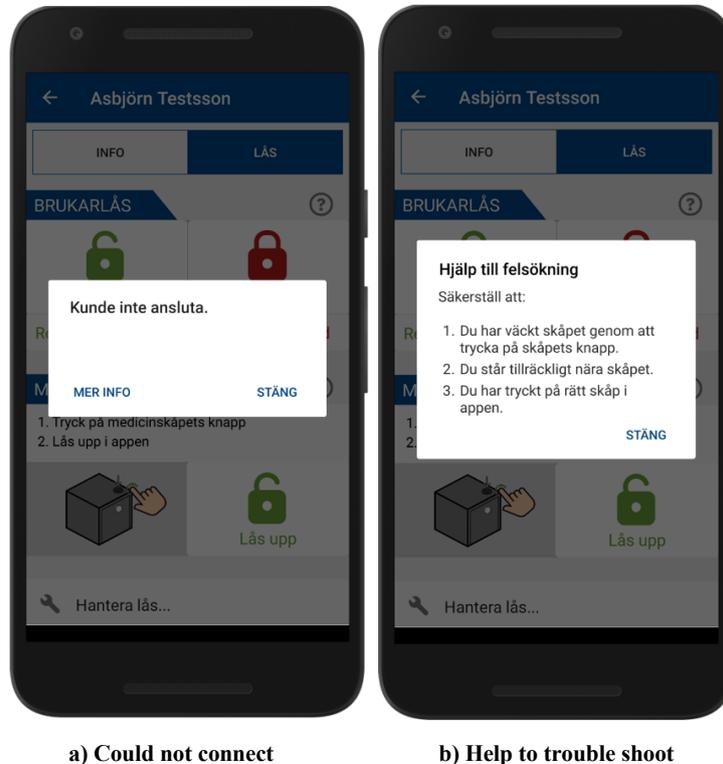


Figure 9.2ab: The updated page for the locks belonging to Asbjörn Testsson for the final proposition, and the pop-up that appears when the question mark is pressed.

If the unlock button in the app was pressed before the button on the cabinet had been pushed, a pop-up appeared, stating that it could not connect. Since the prototype of the app and the cabinet could not communicate, this pop-up would have to be manually placed on the screen by a test leader. Figure 9.3a shows this pop-up, which provided the user with two options. Either they could simply close the pop-up window, or tap on “More info”/“Mer info”. They would then be directed to the pop-up shown in Figure 9.3b.



a) Could not connect **b) Help to trouble shoot**

Figure 9.3a-b: The manual pop-ups placed on the screen by the test leader if the user tried to unlock the cabinet without pushing the button first.

9.2 Evaluation of Final Proposition

9.2.1 Evaluation of Feedback

9.2.1.1 Test Conduction

To determine whether the final proposition had entailed an improvement of the user experience, an evaluation was conducted with three users. In these tests, the final proposition was compared to the original design. However, since the original design had no feedback implemented, it was decided to compare the feedback in the final proposition with feedback inspired by the one in Phoniro's latest product, the Key Safe. Unlike the final proposition, this variant did not have any audio feedback implemented. The two variants included in the tests can be seen in Figure 9.4.

SYSTEM STATUS	FEEDBACK		USER ACTION
	Final Proposition	Key Safe	
Sleeping			Push the button
Awake/waiting			Unlock via app
Authenticating			Wait
Unlocking			Wait
Unlocked			Open
Locking			Wait
Locked			OK to leave

Figure 9.4: The feedback variants in the evaluation.

The evaluating test was performed in a similar way as in the previous user tests, as described in section 7.3 User Tests. The test leaders did not tell the test persons that they participated in a comparative test between the final proposition and the original design. They were only told that they would test two different variants of feedback.

The test person tried the variants of feedback and after each variant, they were asked about how the different colors and eventual sounds were interpreted as well as how they perceived the meaning of a flashing versus constantly shining LED light. When both feedback variants had been shown, the test persons were asked what alternative they preferred.

The test ended with the user trying the final proposition in a dark room, to simulate nighttime. The user was asked how they experienced the audio and LED feedback in a dark environment and whether they preferred both LED and sound, or only one of them. Afterwards, they answered questions about the integrated light. The test leaders revealed the variant that has been developed during the project and asked for suggestions of improvements.

9.2.1.2 Test Results

The test persons in the evaluation had not participated in any previous tests. One had used the Phoniro Medic a few years ago but the others had no experience in healthcare. None of them succeeded in unlocking the cabinet immediately but were guided by the pop-up message. There was no need to interrupt the tests.

Table 9.1: Users in the final test round.

<i>Nbr</i>	<i>Gender</i>	<i>Age range (yr)</i>	<i>Experience in healthcare</i>	<i>Preferred feedback</i>
4.1	Man	≤ 25	No	Final proposition
4.2	Woman	26-40	Yes. Have used Phoniro Medic.	Final proposition
4.3	Man	56-70	Yes	Final proposition

All of them preferred the final proposition rather than the feedback variant as in the Key Safe. Two persons argued that the final variant matched what they had answered to the initial questions about associations with different colors. One user mentioned that it was easier to understand the unlocking when different colors were used for different parts of the process.

The audio feedback was appreciated by all test persons. One did however mention that it was not necessary since the LED provided sufficient feedback, but that the sound captured one's attention. The person further explained that their experience of working as an assistant nurse in ordinary housing was stressful and that it would therefore be convenient to be able hear when the cabinet is unlocked and be able to perform other tasks while waiting. Another test person was content with the fact that that audio feedback was only given when the cabinet was unlocked and locked. They expressed that it would have been bothersome for the staff and care receivers if sound would be played during the entire process. The audio feedback implemented was said to possibly be disturbing for the care receiver, but since the cabinet is unlocked maximum twice per visit it should be fine.

The test persons agreed that it was confusing that the light went off during the unlocking in the Key Safe's feedback design. One mentioned that it was also confusing that blue light was used for two different parts of the process, with the difference that it first was flashing and then lit constantly. They expressed that it did not give the impression of loading when it lit constantly during the authentication. Another user mentioned that they would have preferred another color when initiating the process, since they associated flashing blue with sirens and danger.

The test persons had some suggestions for improvement. One person had problem finding the button on the medicine cabinet due to the insufficient contrast. They suggested that the button could be in a deviating color to make it more visible. They did also suggest that the text "start" could be written next to the button, to signify that the button needs to be pushed to initiate the unlocking. Another suggested that the icon in the app could be zoomed in on the button instead of showing the entire cabinet. The text "help" next to the question marks was suggested by one of the test persons, to inform the users where help can be found. One person mentioned that a tour of the app could be offered the first time the user uses the app. It should be

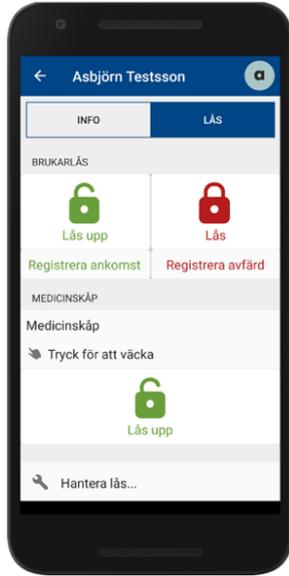
possible to show the tour again to refresh the user's mind, for example after a long leave.

Suggestions to improve the light feedback were also given. Some experienced the light to be very bright at night and suggested that the LED could be dimmed. One test person noticed that there was a difference in pace between the flashing blue and flashing yellow light. They suggested to slow down the pace of the blinking yellow light since a slower pace is less stressful. Another test person suggested placing the integrated lighting on the sides of the cabinet to of reduce shadows from hands.

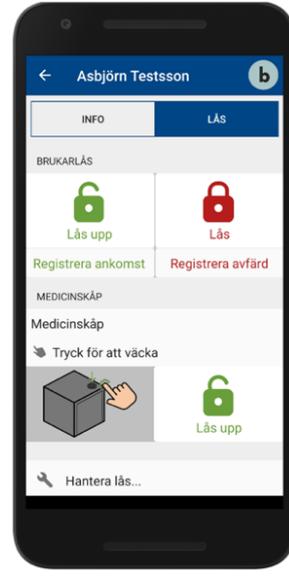
9.2.2 Evaluation of Unlocking Page

9.2.2.1 Test Conduction

The unlocking page for Asbjörn Testsson was updated between the test rounds, based on user opinions. Four different versions (see Figure 9.5a-d) were used and, to evaluate which one was the best, the four versions were sent out to all persons who participated in the user tests. They were asked to rank the versions in the order they preferred them and motivate why they liked their number 1 best. They were also asked for opinions regarding how it could be improved further.



a) The original page



b) Re-designed in the first iteration



c) Re-designed in the second iteration



d) Re-designed in the final proposition

Figure 9.5a-d: The original page and the re-designed pages for the locks belonging to Asbjörn Testsson for the different iterations.

9.2.2.2 Test Results

The share of points each alternative received

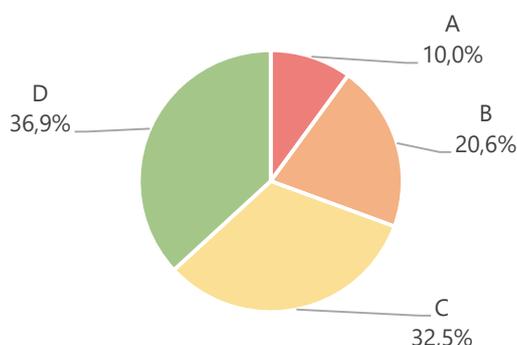


Figure 9.6: The result from the examination about the locking pages.

The unlocking page the test persons ranked as number 1 got 4 points, the second got 3 points and so on. The points from all participants were summarized, and the results of the share of points each alternative received is shown in Figure 9.6. Option D received 36.9 % of the points and won the vote, but C was not far behind. The motivation most test persons gave for picking D as their number 1 was that it was the clearest and had unambiguous instructions. They said that it was clear that one should first push the button *on the cabinet* and then the button *in the application*. Those who on the other hand preferred option C considered D's instructions to be overly clear, and that they could be annoying in the long run. On the other hand, it was also stated by a few other persons that it was easy to miss the instructions in option C.

Several expressed that the highlighted headings in C and D attracted more attention and thereby helped the user find the desired product. A couple of users also pointed out that the added knob in D helped them understand that it was the medicine cabinet the icon represented. It was however stated that the icon helped gain an understanding of how to unlock in both page B, C and D. One user said that the icon was "absolutely necessary in order to know where to press". The icon shows where the button is located but pointers were given regarding that an increased contrast would have made it more visible.

Most agreed that the prompt "Tryck för att väcka"/"Press to wake" in page A and B was confusing. Some said that the word "wake" was inexplicit and almost all agreed that the fact that it does not communicate where one should interact entails that it is easily misunderstood. Several stated that the design in A was likely to lead to the user simply pressing the unlock-button in the application.

10 Discussion

10.1 Methods

10.1.1 Product Evaluation

In the first stage of the design process, the product evaluation, the only evaluators involved were the two team members. It would have been better to involve more evaluators, since this would have revealed additional user problems. According to Jakob Nielsen, one user usually discovers a third of all usability problems and two users about 50 % [26]. Taking cost versus results into consideration, it is argued that five users are ideal in usability testing.

The purpose of the initial product evaluation was partly to discover the products' strengths and weaknesses but mainly to decide what product the team would choose to develop further. Once Medic Mini was chosen, the main part of the project could be initiated. Since the team themselves had evaluated all products in the first stage of the process, they gained an overview of the products and an understanding of largely what problems existed in general. This was in its turn a big help in the future process since being familiar with several of the company's products, as well as grasping the company's general design language, was valuable knowledge. However, the main part of the project was, as mentioned, the product development of Medic Mini and since reaching out to users and analyzing the collected data is time consuming, it was prioritized to gather user opinions at this stage of the process.

10.1.2 Interviews

Interviews are preferably conducted in person to perceive body language and personal expressions [13, p. 102]. Due to Covid-19, the interviewees were however asked to participate digitally via Zoom video call. One of the interviewees did not have access to a computer or video equipment and the interview was therefore conducted by phone. This entailed that the interviewee's body language could not be seen. Zoom is a good alternative to face-to-face sessions since it enables video and screen-sharing, but poor connections can cause challenges. On the other hand,

an advantage of remote interviewing is that the participants do not have to travel and often are more relaxed since they are in their own environment [5, p. 277].

10.1.3 Personas and Scenarios

When generating concepts, the personas and different scenarios were held in mind. This was however done during discussions and brainstorming sessions. The different scenarios were however not presented in writing, and no storyboards were created. This could have been done in order to help picture the different ways the product can be used, and potential challenges it faces. The different scenarios were however staged during the user tests as nighttime was simulated and the test person was asked to unlock the cabinet and retrieve medicine in order to feed it to the fictive care receiver.

The personas were considered when the design was continuously updated but could also have been used later in the process to make additional evaluations of the prototype. This was however not done due to time limitations.

10.1.4 User Tests

The user tests were conducted in several iterations since the users' feedback were taken into consideration. When enough information had been gathered, and it was clear what changes should be made, the prototype was re-designed and a new round of tests were initiated to evaluate the new concepts. In the first and second round of tests, only 2-3 persons participated. This was because the concepts were less elaborated, and problems were identified faster.

In test round 3, eight persons participated. Even more tests were planned to be conducted, but the supervisor suggested the team to advance to the next step since little new information is gathered after that many tests [26]. Looking back, fewer tests should probably have been conducted in the third test round, since a clear pattern regarding the preferred variant of feedback had already been identified and there were little surprises in the finishing tests. If fewer persons had participated in this test, more could have participated in the evaluation of the final concept instead. Here, only three persons participated.

The results of the tests can probably be considered quite objective since the order of the different feedback variants was varied in order not to affect the results. The fact that the test persons did not belong to the target group might have affected the results to some extent but mostly, the test did not investigate things that acquired knowledge within the area of home care. How a user perceives colors and feedback does likely not differ between home care staff and other people. The ability to

picture oneself in the presented scenarios in the test would however be easier for a person who has experience of being in a similar situation.

10.2 Prototyping and User Tests

10.2.1 Audio Feedback

Auditory feedback can result in the user having a hard time determining what device created the sound. Light feedback might also lead to the user entirely missing the feedback, if their eyes are not looking at the right spot at the right time [12, pp. 23-24]. The combination of the two does however create a multi-sensory feedback, which makes it more likely to notice at least one of them. It was contemplated whether users would consider sound feedback to be disturbing, but no user mentioned this in the tests. How many times a user unlocked the cabinet with audio feedback depended on how many times they wished to repeat the process to evaluate the different options. Many users did however only do this a few times in total. One could thereby argue that, since they were not exposed to the feedback repeatedly, this was not a fair way to test it. The sounds were nonetheless made short to enhance the repetitive tolerance for the users, and to prevent the sounds from being an annoying addition.

When a lock is unlocked, a mechanical sound can be heard. Since there was no working locking mechanism in the cabinet, the test persons had to rely on the implemented feedback in the cabinet and the app. In reality, the mechanical sound would likely have facilitated the interaction further since it also confirms that something has happened.

10.2.2 LED Feedback

10.2.2.1 Colors

It was asked what color the users in the tests associated with different system statuses. In order not to influence the users' responses, this was asked before the interacting part of the test, where they were shown the different feedback options. The results, presented in Figure 8.4, showed that all users agreed that "Unlocked" and "Succeeded" should be represented with the color green. Most users also agreed that red was connected to both "Locked" and an "Error message". Most users responded to these with little to no hesitation. However, regarding the system statuses "Connecting" and "Loading", the users did not reply as quickly. They were not as sure what to answer but nonetheless, it seemed like the colors blue and yellow

were the most popular options for both statuses. Yellow dominated in the loading process and blue in the connection process. Many users motivated their choice for the loading process with the traffic light metaphor, where yellow is in-between the signals for “stop” and “go”. The relationship between the connection process and the users’ preferred color was not as obvious but some conveyed that they made the connection to Bluetooth, which is highly associated with blue.

The only color that was implemented for the connection process in the user tests was blue, with either a constant or flashing light. It could be motivated that more colors should have been tried but during the three test rounds, nobody suggested that they would have preferred another color after trying the different options. Pointers were rather given regarding the color for the loading process, which was thereby varied to a higher extent.

Trying to fulfill the wishes of *all* users were discovered to be impossible. At a few instances, the wish of one user turned out to be what another user complained about. For example, one user in the feedback evaluation of the final proposition said that they associated a blue blinking light with sirens on an ambulance. Many users in the previous tests had rather said that blue was a calm color, that mediates that everything is going as it should. The conclusion drawn was that the feedback might not please all users since they have different associations and experiences. The fact that 88 % preferred blue light for the connection process and yellow for the unlocking and authentication processes pointed towards this being a widely accepted option. The exact variant in the final proposition, with the blue light *blinking* during the connection process, was preferred by 65 %, which was also good statistics.

Only 15 % in the second and third round of user tests considered the feedback inspired by the Key Safe to be the clearest (see Figure 8.2). One reason why it got so few votes was that several users stated that they got confused when the LED was turned off during the unlocking process. Some of them thought that something went wrong and that the process had ended, while others noticed that the process was still ongoing in the app. A clear pattern from the test results was that the users appreciated LED feedback during the entire process.

Due to the pandemic, the tests were only performed on persons in the team’s surrounding and none of them were color blind. Hence, this group was not reached and valuable opinions from people who had problem distinguishing the different LED colors were lost. Some difference in the frequency of the blinking lights was implemented to separate the connection process from the unlocking process but this was not noticed by more than a couple persons. The reason for this was probably that the change of color attracted their attention instead. Little opinions were thereby gathered within the area. However, sound feedback was implemented when the LED lit green and red to communicate to these users that the cabinet was locked or unlocked.

10.2.2.2 *Blinking versus constant light*

Regarding blinking versus constant light, it was discovered that it was consistent through all iterations that users considered blinking light to attract more attention. It was also a general opinion that it mediated that an “active process” was occurring while the constant light mediated that the process was finished.

It varied whether the users wanted the LED feedback for the push of the button to be constant or flashing. Many said that they liked that the flashing light caught their attention. Some users made the connection that, when a process was finished, the constant light was a prompt that it was their turn to act. This was a motivation that they considered that the light should be constant when the button was pushed, since they were yet supposed to tap the unlocking button in the application. Most users did however prefer the blinking light to the constant one for this part of the process. One user specifically identified that they thought as previously described, but that they yet preferred the flashing light without really knowing why. A possible reason that people preferred the flashing blue light for the connection process can be that it is recognized from the pairing between a phone and a Bluetooth unit, such as a speaker or headphones. For the loading process, the blinking light was clearly preferred and based on mere statistics, it was assumed that the flashing light was the best alternative when the button had been pushed.

10.3 Final Proposition

10.3.1 Adjustable Feedback

Some users stated that the LED light was dazzling during the simulated nighttime. Nobody said that the sound disturbed them but pointed out that the care receiver might experience it differently. Solutions were discussed with a few test persons and the conclusion reached was that the volume and brightness should be adjustable. This would enable easy and pleasant use of the product both during the day and night. To entirely remove one feedback might confuse the user due to the inconsistency. To amplify or reduce the sound and brightness based on the current surroundings might however be less confusing. Alternatively, a volume and brightness that is sufficient to be noticeable during daytime but discreet enough not to disturb during the night can be implemented.

10.3.2 Unlocking Page

It was a fairly even vote (see Figure 9.6) between the options C and D in the evaluation of the unlocking page. The main reason why the test participants stated that they preferred option D was that they considered it to have clear, unambiguous instructions. Many persons who said they preferred option C did however state that they thought the instructions in D were *overly* clear. Whether something is overly explained or simply clear seemed to be arguable. Many users did fail to unlock the cabinet properly the first time, so one could argue that clear instructions would be a good thing. However, when the test persons had unlocked the cabinet successfully once, they considered it to be an easy process. Once you are an “experienced user”, it seems obvious how to perform the different actions.

The interface should preferably be customizable, to suit both novice and experienced users. This could be solved by a pop-up, like the one in the first iteration, with the alternative to dismiss the pop-up in the future. The question mark icon in option D is also helpful for the novice user but can be ignored by those who know how to unlock the cabinet. The appearance of an explaining animation the first time the application is opened is also an alternative to solve this problem. However, in this project, option D was chosen as the final concept since it was the clearest one according to almost all users. It was also argued that its instructions can be ignored by more experienced users and do not acquire any extra taps for those who already know how to proceed.

10.4 Evaluations

In the user tests, it was examined whether the users left the cabinet open when they gave the fictive care receiver medicine or not. The results did however vary much. One could argue that the test environment did not properly simulate the actual home of a care receiver and that the test participants were not experienced home care staff. However, the conclusion from the tests and the interviews were regardless that the most secure solution to inform the staff of the medicine cabinet’s unlocked state would be to simply send a message to the staff in the application. In this way, the staff would be informed but not the care receivers.

It was discussed whether the cabinet should provide feedback when it is not properly closed, or not. At first, it sounded like a great idea to implement that the cabinet’s LED flashed red and that a beeping sound started to sound when this happened. However, after a few interviews, it was understood that the length of a visit in a care receiver’s home varies much. It was thereby hard to determine how long it should take before the alarm started. If the alarm is set off too soon, it could be initiated when the staff provides the care receiver with medicine, if they leave the door open.

If it, on the contrary, takes too long there is a risk that the staff has already left when the alarm starts. This will likely disturb the care receiver and force the staff to return and stop the alarm, if this cannot be done remotely. It might also entail that the care receiver is informed of the cabinet's unlocked state and that their medicines are left unattended.

11 Conclusion

The purpose of the master thesis was to improve the user experience in one of Phoniro's products. Three widely accepted lists of guidelines were used for inspiration to create a customized list of heuristics: *The Principles for Universal Design*, *Jakob Nielsen's Ten Usability Heuristics* and *Don Norman's Design Principles*. The result was a compiled list of 14 heuristics, which were used to evaluate the Phoniro Lock, Key Safe, Medic Mini and the Home Care application.

After evaluating all products, Medic Mini was considered to have the greatest development potential and was therefore chosen for further development. It was decided to focus on the feedback since this was not implemented, and good feedback has great potential of enhancing the user experience. Some focus was put on the application as well since the user experience of the medicine cabinet is highly correlated to the design of the application, and the communication between the two.

Regular users were interviewed to gain insights into the users' needs and opinions regarding the medicine cabinet and use this as a foundation for the development. The data collected from the interviews were analyzed, needs were extracted, and personas were created. For each identified need, concepts were brainstormed with the personas held in mind.

A hi-fi prototype was created, and different variants of LED and audio feedback were implemented. A prototype of the app was created, and the unlocking page was redesigned. These prototypes were tested in three iterations with a total of 13 users and were updated between the different test rounds according to the test persons' results and suggestions. After the third round of tests, a final proposition was made based on the user test results. This was evaluated through a final round of user tests with three users.

Since the original medicine cabinet did not have any feedback implemented, the final proposition is considered to improve the user experience. LED feedback throughout the unlocking process was considered to be clearest by the users. The implementation of audio feedback when the cabinet was unlocked and locked was preferred since it captures the user's attention and ensures that they do not miss the feedback, if they are not looking at the LED. However, the sound and brightness should be adjustable to make the use of the product convenient in different environments and surrounding light.

The final proposition flashes blue during the connection process and flashes yellow during the loading process. When the cabinet is unlocked, the LED lights green combined with a short and subtle upwards sound and when it is locked, the LED lights red combined with a short downwards sound. Yellow, flashing light was by far the most popular among users for a loading process and blue for the connection process. Whether the users thought this would light constantly or flash varied but the flashing light was preferred by 80 %.

The re-designed unlocking page (page D) also enhanced the user experience since the users considered it to have clear, unambiguous instructions compared to the original. The original page's prompt to press the button on the cabinet should be rephrased since it does not communicate where one should interact, and the word "wake" is inexplicit. This entails that the procedure is easily misunderstood.

The integrated light was appreciated since it made it easy to see inside the cabinet regardless of the ambient light. It contributed to the process of finding a specific medicine being easier and faster.

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Appendix A Work Distribution and Time Plan

Work Distribution

The members of the team have been equally involved in all activities during this thesis. Occasionally the tasks have differed slightly, but all activities have been discussed thoroughly by both members. The tasks were divided during the construction of the prototype. What components should be implemented, and the design of the prototype, was jointly determined. Eleonor was however in charge of writing the code for the Arduino while Daniella focused on 3D printing components and planning the test setup. Eleonor focused on the presentation of the results from the tests in the form of diagrams, while Daniella was responsible for making the layout for the illustrations in the report.

Project Plan and Outcome

The planned and performed activities can be seen in Figure A.1-3. The filling color represents the planned timeline, and the outlines represents the performed.

PROJECT TIMELINE MASTER THESIS

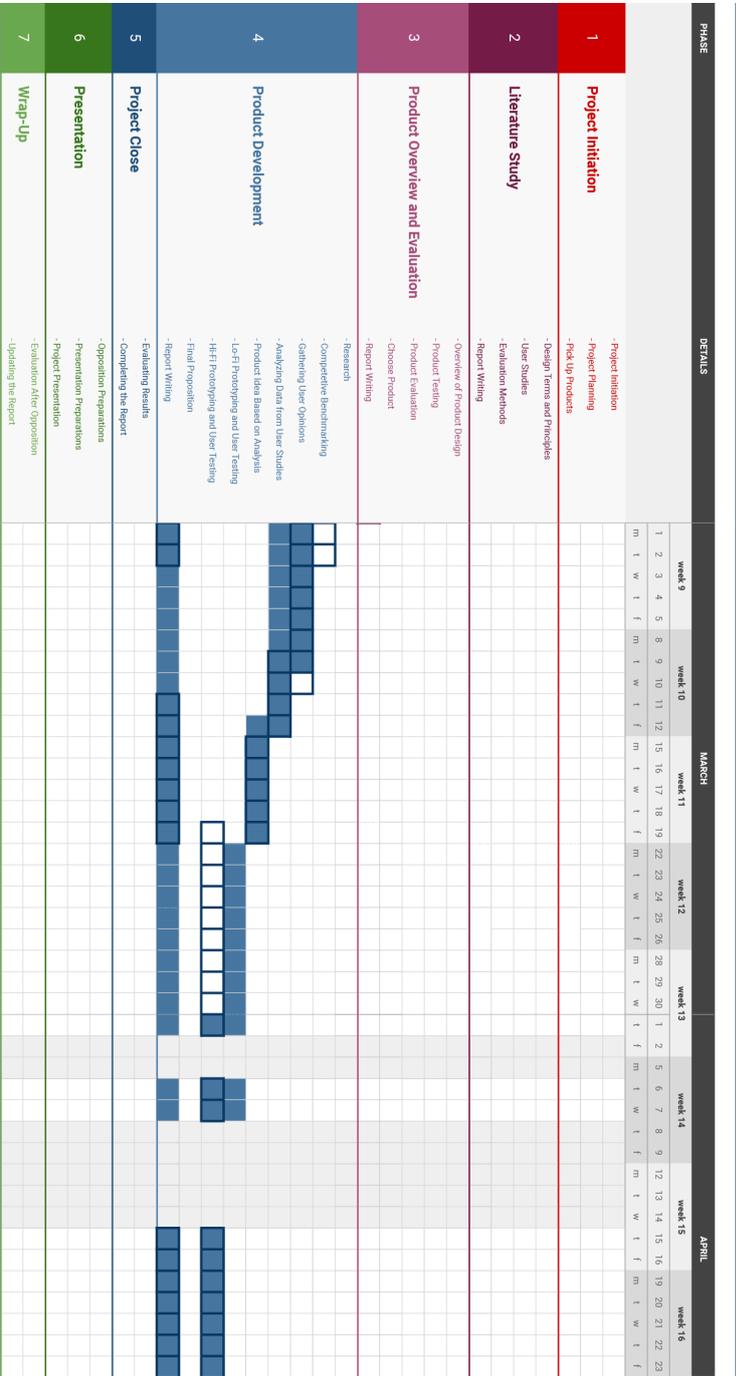


Figure A.2: Planned and performed activities for week 9-16.

Appendix B Compiled Design Principles

The three evaluation methods: Principles for Universal Design, Jakob Nielsen's Ten Usability Heuristics and Don Norman's Design Principles compiled into one. Since some of the principles overlapped, the main principle was selected as a head principle and those that were related as subprinciples. Some subprinciples are related to more than one main principle. What started as 24 principles ended up being 14 after the compilation.

1. Discoverability (Visibility)

The relevant components must be visible and communicate what actions are possible.

- *Perceptible Information*
Necessary information should be effectively communicated to the user, regardless of ambient conditions or the user's sensory abilities.
- *Visibility of System Status*
Designs should keep users informed about what is going on.
- *Simple and Intuitive Use*
Arrange information consistent with its importance. The iconography should be intuitive.
- *Recognition Rather Than Recall*
Minimize the user's memory load by making elements, actions, and options visible. Avoid making users remember information.
- *Aesthetic and Minimalist Design*
Interfaces should not contain information that is irrelevant. Every extra unit of information in an interface competes with the relevant units of

information. The visibility of interface elements that are the most important for the user experience should be prioritized.

2. Feedback

Feedback is letting the user know that the system is working on their request. The result of an action must be immediate since even a small delay can be disconcerting.

Possible indication methods:

- Audial feedback
- Visual feedback
- Tactile feedback

- *Visibility of System Status*
Keep the user informed about what is going on through appropriate, timely feedback. The user is never left guessing of taken actions and their consequences.
- *Simple and Intuitive Use*
Provide feedback during and after tasks.
- *Tolerance for Error*
Provide warnings.
- *Aesthetic and Minimalist Design*
Every extra unit of information (feedback) competes with the relevant units of information.
- *Recognize, Diagnose and Recover from Errors*
Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.

3. Conceptual Model (mainly metaphors)

A conceptual model is an explanation of how something works, usually highly simplified. Helpful metaphors can be implemented to make the mental model of the system easily understood.

- *Match Between System and the Real World*
The design should speak the users' language. Use words, phrases, and concepts familiar to the user, rather than internal jargon.
- *Consistency and Standards*

Follow platform conventions. Check-in counters are usually located at the front of hotels, which meets expectations.

4. Affordances

The proper affordances exist to complete the desired actions. Affordances refer to the relationship between the properties of the object and the capabilities of the user.

5. Signifiers

It should be easy to intuitively figure out how to use the product. Indicators providing clues, and attributes of the object help people understand how to use it.

- *Simple and Intuitive Use*
It is easy to understand how one should use the design, regardless of experience, knowledge, current concentration level or language skills.

6. Mapping

Clear relationship between controls and the effect they have on the world. The mapping should be made as natural as possible.

- *Match Between System and the Real World*
Use words concepts familiar to the user. (Users can quickly understand which stovetop control maps to each heating element.)

7. Constraints

By limiting the range of possible interactions, they simplify and guide the user to the appropriate action.

- *Aesthetic and Minimalist Design*
Interfaces should not contain information which is irrelevant. Every extra unit of information in an interface competes with the relevant units of information.

8. Equitable Use

It provides identical means of use for all users when possible, equivalent when not.

9. Flexibility in Use

The design allows for a wide range of individual preferences and abilities.

- *Flexibility and Efficiency of Use*
Shortcuts hidden from novice users, speeds up interaction for experienced users.

10. Tolerance for Error

The design minimizes hazards and the negative consequences of unintended actions. Provide warnings and fail-safe features.

- *User Control and Freedom*
Users often perform actions by mistake. They need a clearly marked “emergency exit” to leave the unwanted action.
- *Error Prevention*
Good error messages are important, but the best designs carefully prevent problems from occurring in the first place.
- *Recognize, Diagnose and Recover from Errors*
Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.

11. Low Physical Effort

The design can be efficiently and comfortably used with a minimum of fatigue. Minimize repetitive actions etc.

12. Size and Space for Approach and User

Appropriate size and space are provided to approach, reach, manipulate, and use regardless of the user’s body size, posture, or mobility.

13. Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

14. Help and Documentation

It's best if the design doesn't need any additional explanation. However, it may be necessary to provide documentation to help users complete their tasks.

Appendix C Script for Interviews

Hej!

Vi heter Eleonor och Daniella och gör ett examensarbete för Phoniro. Vi vill förbättra interaktionen mellan Phoniros medicinskåp och användaren, och då framför allt hur medicinskåpet kommunicerar vad som sker (när det går att öppna, när det är låst osv). Med den här intervjun vill vi få en inblick i vår målgrupps tankar och hur ni som faktiskt arbetar med produkten uppfattar den, samt digitalisering av arbetet generellt. Datan som samlas in från kommer att ligga till grund för utvecklingen av produkten.

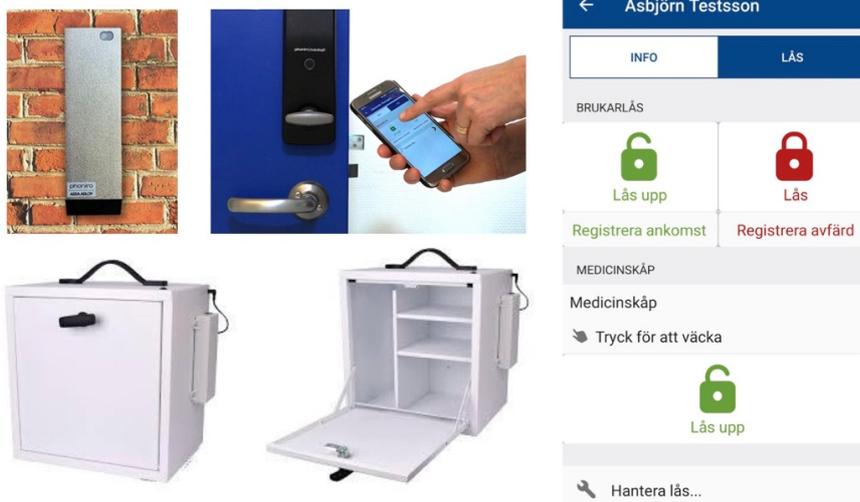
För att göra intervjun så effektiv som möjligt undrar vi om det går bra att vi spelar in intervjun och för att kunna transkribera i efterhand?

Inledande personliga frågor

1. Vad heter du? (För att hålla reda på inspelningarna)
2. Vilken är din arbetsroll? (montör, ta hand om vårdtagare osv)
3. Vilken arbetsplats arbetar du på? (hemtjänst, särskilt boende osv)
4. Hur gammal är du och hur länge har du arbetat inom yrket?
5. Har upplåsningen skett digitalt under hela din tid inom yrket?
6. Kan du berätta lite (kort) om hur en vanlig dag på jobbet kan se ut.

Om Phoniros produkter och generell inställning till teknik

För att säkerställa att vi pratar om samma produkter kommer vi nu visa en bild på några av Phoniros produkter.



7. Känner du igen alla produkterna? Har du använt alla produkter?
8. Använder du appen när du låser upp?
9. Vad är dina åsikter kring digital upplåsning istället för fysisk nyckel? (Både medicinskåp och andra produkter generellt)
10. Vad är din inställning till digitalisering inom vården generellt? (sköta bl a handling, upplåsning, journal digitalt)
11. Vad är din inställning till teknik allmänt? Ser du dig själv som en teknisk person?

Om medicinskåpet

12. Har du använt Phoniros medicinskåp? Om ja, hur ofta? (varje dag, någon gång ibland?)
13. Tycker du det är tydligt hur man ska gå tillväga för att låsa upp och öppna medicinskåpet? (Vilken ordning man utför handlingar, hitta rätt användare, trycka på knapp, vrida på handtag osv)
14. Tycker du att det tydligt förmedlas när medicinskåpet är låst och upplåst?
15. Tror du att ytterligare feedback, t ex ljud eller ljus, hade kunnat förtydliga specifika moment i låsnings- eller upplåsningsprocessen? (Någon specifik del som är otydlig?)
16. Förutsätt att ytterligare feedback ska implementeras - skulle du föredra feedback i form av ljud eller ljus i olika färger? Ha gärna i åtanke vilken omgivning du befinner dig i när du arbetar.
17. Är det någon funktion du saknar i medicinskåpet eller i Phoniros andra produkter?
18. Har du några övriga tankar? Är det någonting mer du vill tillägga som du har tänkt på när du använt medicinskåpet som vi inte redan berört?

Appendix D Flow Chart of the Unlocking and Locking Process

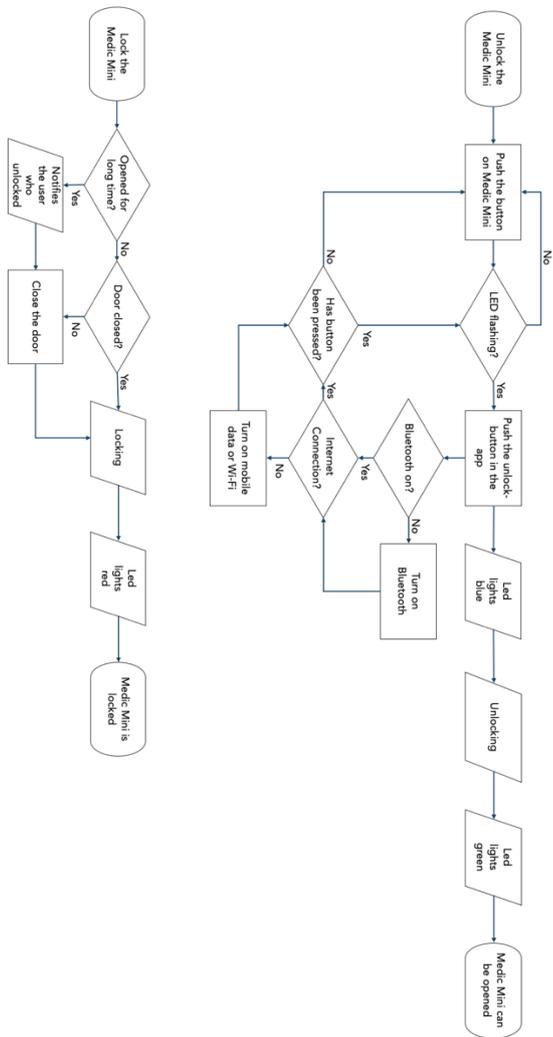


Figure D.1: Flow chart of the unlocking and locking process.

Appendix E Arduino Code

```
/* Final proposition */

// constants won't change. Used to set pin numbers:
const int microSwitchPin = 2; // NO to pin and C to ground
const int buttonMedicPin = 4;
const int buttonLeaderPin = 7;
const int redLightPin = 5;
const int greenLightPin = 10;
const int blueLightPin = 9;
const int LEDListPin = 6;
const int melodyPin = 11;

const int nbrOfPixels = 9;
boolean doorOpened = false;

#include <Adafruit_NeoPixel.h>
Adafruit_NeoPixel pixels(nbrOfPixels, LEDListPin, NEO_GRB + NEO_KHZ800);

void setup() {
  pinMode(microSwitchPin, INPUT);
  pinMode(buttonMedicPin, INPUT);
  pinMode(buttonLeaderPin, INPUT);
  pinMode(LEDListPin, OUTPUT);
  pinMode(redLightPin, OUTPUT);
  pinMode(greenLightPin, OUTPUT);
  pinMode(blueLightPin, OUTPUT);
  pinMode(melodyPin, OUTPUT); // speaker
  pixels.begin();
  lightOff();
}

void loop() {
  if (buttonMedic()) {
    if (flashingBlue()) {
      flashingYellowSlow();
      green();
    }
  }
}
```

```

        delay(500);
        unlockingAudio();
        unlock();
        red();
        delay(500);
        lockingAudio();
        delay(1500);
        lightOff();
    }
}
if (doorOpenedUnlocked(doorOpened)) {
    red();
    alarmAudio();
    delay(200);
    lightOff();
    delay(200);
}
doorOpened = false;
}

/* Button methods */
boolean newButtonStateA = LOW;           // the current reading from the input pin
boolean newButtonStateB = LOW;           // the current reading from the input pin
boolean newButtonStateC = LOW;           // the current reading from the input pin
boolean lastButtonMedicState = LOW;      // the previous reading from the input pin
boolean lastButtonLeaderState = HIGH;    // the previous reading from the input pin

// methods
boolean buttonMedic() {
    boolean activatedButton = false;

    newButtonStateA = digitalRead(buttonMedicPin);
    delay(1);
    newButtonStateB = digitalRead(buttonMedicPin);
    delay(1);
    newButtonStateC = digitalRead(buttonMedicPin);

    if ((newButtonStateA == newButtonStateB) && (newButtonStateA == newButtonStateC)) {
        if (newButtonStateA != lastButtonMedicState) {
            if (newButtonStateA == LOW) {
                activatedButton = true;
            }
        }
        lastButtonMedicState = newButtonStateA;
    }
}

```

```

    digitalWrite(buttonMedicPin, HIGH);
    return activatedButton;
}

boolean buttonLeader() {
    boolean activatedButton = false;

    newButtonStateA = digitalRead(buttonLeaderPin);
    delay(1);
    newButtonStateB = digitalRead(buttonLeaderPin);
    delay(1);
    newButtonStateC = digitalRead(buttonLeaderPin);

    if ((newButtonStateA == newButtonStateB) && (newButtonStateA == newButtonStateC)) {
        if (newButtonStateA != lastButtonLeaderState) {
            if (newButtonStateA == HIGH) {
                activatedButton = true;
            }
        }
        lastButtonLeaderState = newButtonStateA;
    }
    digitalWrite(buttonLeaderPin, LOW);
    return activatedButton;
}

/* RGB LED Methods */

void RGB_color(int redLightValue, int blueLightValue, int greenLightValue) {
    analogWrite(redLightPin, 255 - redLightValue);
    analogWrite(greenLightPin, 255 - greenLightValue);
    analogWrite(blueLightPin, 255 - blueLightValue);
}

void blue() {
    RGB_color(0, 0, 100); // blue
}

void green() {
    RGB_color(0, 100, 0); // green
}

void red() {
    RGB_color(100, 0, 0); // red
}

```

```

void yellow() {
  RGB_color(255, 100, 0);
}

void lightOff() {
  RGB_color(0, 0, 0); // off
}

boolean flashingBlue() {
  int counter = 0;
  boolean cancel = false;

  while (!cancel && counter < 10) {
    blue();
    for (int i = 0; i < 200; i++) {
      if (buttonLeader()) {
        cancel = true;
        break;
      }
    }
    lightOff();
    for (int i = 0; i < 200; i++) {
      if (buttonLeader()) {
        cancel = true;
        break;
      }
    }
    counter++;
  }
  return cancel;
}

void flashingYellowSlow() {
  for (int i = 0; i < 5; i++) {
    yellow();
    delay(750);
    lightOff();
    delay(750);
    if (doorOpenedUnlocked(doorOpened)) {
      red();
      alarmAudio();
      delay(200);
      lightOff();
      delay(200);
    }
  }
}

```

```

    }
  }
}

boolean unlock() {
  boolean openedTooLate = false;
  while (!(openedTooLate || doorOpened)) {
    for (int i = 0; i < 3000; i++) {
      if (microSwitch(doorOpened)) {
        doorOpened = true;
        lightStrip();
        delay(2000);
        lightOff();
        break;
      } else if (i == 2999) {
        openedTooLate = true;
        break;
      } else {
        delay(10);
      }
    }
  }
  while (doorOpened && !openedTooLate) {
    lightStrip();
    if (!microSwitch(doorOpened)) {
      offStrip();
      break;
    }
  }
  openedTooLate = false;
}

/* LED Strip Methods */

void lightStrip() {
  digitalWrite(LEDListPin, HIGH); //test

  pixels.clear();
  pixels.setBrightness(40);
  for (int i = 0; i < nbrOfPixels; i++) {
    pixels.setPixelColor(i, pixels.Color(220, 120, 50));
  }
  pixels.show();
}

```

```

void offStrip() {
    digitalWrite(LEDListPin, LOW); //test

    pixels.clear();
    //pixels.setBrightness(80);
    for (int i = 0; i < nbrOfPixels; i++) {
        pixels.setPixelColor(i, pixels.Color(0, 0, 0));
    }
    pixels.show();
}

/* Micro Switch Methods */
boolean switchState = LOW;

boolean microSwitch(boolean openDoor) {
    if ((digitalRead(microSwitchPin) == LOW) && (switchState == 0)) {
        switchState = HIGH;
        openDoor = false;
        delay(20);
    }
    if ((digitalRead(microSwitchPin) == HIGH) && (switchState == 1)) {
        switchState = LOW;
        openDoor = true;
        delay(20);
    }
    digitalWrite(microSwitchPin, HIGH);
    return openDoor;
}

boolean doorOpenedUnlocked(boolean openDoor) {
    if ((digitalRead(microSwitchPin) == LOW)) {
        switchState = HIGH;
        openDoor = false;
        delay(20);
    }
    if ((digitalRead(microSwitchPin) == HIGH)) {
        switchState = LOW;
        openDoor = true;
        delay(20);
    }
    digitalWrite(microSwitchPin, HIGH);
    return openDoor;
}

/* Audio Methods */

```

```

boolean larm = false;

#define NOTE_C5 523
#define NOTE_D5 587
#define NOTE_E5 659
#define NOTE_F5 698
#define NOTE_G5 784
#define NOTE_DS8 4978

// Array melodies and tempo
int unlockMelody[] = {
    NOTE_F5, NOTE_C5, NOTE_G5
};

int unlockTempo[] = {
    8, 8, 6
};

int lockMelody[] = {
    NOTE_D5, NOTE_E5, NOTE_C5
};

int lockTempo[] = {
    8, 8, 6
};

int alarmMelody[] = {
    NOTE_DS8
};

int alarmTempo[] = {
    3
};

void unlockingAudio() {
    int size = sizeof(unlockMelody) / sizeof(int);
    for (int thisNote = 0; thisNote < size; thisNote++) {
        // to calculate the note duration, take one second divided by the note type.
        int noteDuration = 1000 / unlockTempo[thisNote];
        buzz(melodyPin, unlockMelody[thisNote], noteDuration);
        // stop the tone playing:
        buzz(melodyPin, 0, noteDuration);
    }
}

```

```

void lockingAudio() {
    int size = sizeof(lockMelody) / sizeof(int);
    for (int thisNote = 0; thisNote < size; thisNote++) {
        // to calculate the note duration, take one second divided by the note type.
        int noteDuration = 1000 / lockTempo[thisNote];
        buzz(melodyPin, lockMelody[thisNote], noteDuration);
        // stop the tone playing:
        buzz(melodyPin, 0, noteDuration);
    }
}

void alarmAudio() {
    int size = sizeof(alarmMelody) / sizeof(int);
    for (int thisNote = 0; thisNote < size; thisNote++) {
        // to calculate the note duration, take one second divided by the note type.
        int noteDuration = 1000 / alarmTempo[thisNote];
        buzz(melodyPin, alarmMelody[thisNote], noteDuration);
        // stop the tone playing:
        buzz(melodyPin, 0, noteDuration);
    }
}

void buzz(int melodyPin, long frequency, long length) {
    // calculate the delay value between transitions
    // 1 second's worth of microseconds, divided by the frequency,
    // then split in half since get the total number of cycles to produce
    long delayValue = 1000000 / frequency / 2;
    // calculate the number of cycles for proper timing
    // multiply frequency, which is really cycles per second,
    // by the number of seconds to get the total number of cycles to produce
    long numCycles = frequency * length / 1000;

    for (long i = 0; i < numCycles; i++) { // for the calculated length of time...
        digitalWrite(melodyPin, HIGH); // write the buzzer pin high to push out the diaphragm
        delayMicroseconds(delayValue); // wait for the calculated delay value
        digitalWrite(melodyPin, LOW); // write the buzzer pin low to pull back the diaphragm
        delayMicroseconds(delayValue); // wait again on the calculated delay value
    }
}

```

Appendix F User Test Framework

Testperson:

Ordningen på de olika LED-varianterna varierade under de olika testen. En ordning kunde vara:

LED 1 = 3.4

LED 2 = 3.1

LED 3 = 3.2

LED 4 = 3.3

Inledande intervjufrågor

Får vi spela in?

Hur gammal är du?

≤ 25

26-40

41-55

56-70

Vilken färg tycker du hör ihop med följande (blanda ordningen)?

Felmeddelande:

Lyckades/färdigt:

Kopplar upp/connectar (Bluetooth t.ex):

Låst:

Laddar/vänta:

Upplåst:

Följdfråga om någon/några av färgerna grönt, rött, blått eller gult inte nämndes bland testpersonens svar i föregående fråga:

Vilka associationer har du till färgen (ex. blått), dels generellt men även i tekniska sammanhang?

Interaktion

Dina inloggningsuppgifter är:

Användarnamn: medic

Lösenord: 123

Du är hemma hos Asbjörn Testsson. Du har kommit in genom hans ytterdörr genom att låsa upp ytterdörren med appen. Du ska låsa upp Asbjörn Testssons digitala medicinskåp (peka). Du låser upp skåpet via Phoniros app "Home Care".

Ta god tid på dig, känn dig inte stressad. Prata gärna högt (think aloud) om vad du tänker under interaktionen. Glöm inte bort att även kolla på LEDen under upplåsningprocessen.

De olika LED-varianterna

Börja med att enbart testa LED-varianterna och dra ur sladden till högtalaren.

Vad tycker du om LED 1? Förstod du vad som hände under de olika delarna av processen? Vad tolkade du det som att de olika färgerna betydde? (blå, gul, grön, röd, konstant/blink)

Vad tycker du om LED 2? Förstod du vad som hände under de olika delarna av processen?

Vilken variant av LED-feedback föredrar du?

1

2

Varför?

Nattetid

Släck ner och mörklägg rummet. Belysningen inne i skåpet ska inte vara inkopplat.

Det är nu natt och du kommer på ett nattbesök för att ge Asbjörn medicin. Asbjörn ligger och sover (peka) och du ska ge honom medicin (ex. BamyI). Väck Asbjörn och ge honom sin medicin.

Hur upplever du ljus- och ljudfeedback nattetid? Var någon av dem störande för dig eller den fiktiva brukaren?

Vilken typ av feedback föredrog du nattetid?

LED

LED + ljud

(Ljud)

Ingen

Integrerad belysning

Koppla in belysningen.

Asbjörn har ett till nattbesök med medicin. Väck Asbjörn och ge honom sin medicin (ex. Pamol).

Tycker du belysningen i skåpet gjorde stor skillnad?

Föredrar du att det finns integrerad belysning i skåpet?

Med belysning

Utan belysning

Vet ej

Varför?

Kommentarer och observationer