Designing cooperative and shared living for households that include both people with and without visual impairments

by

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Abstract

From the 20st century, organizations have been established for helping people with visual impairments. However, people with sight who are living with people who are visually impaired haven't gotten much attention and appropriate training about how to deal with the new living situations. Studies show that people both with and without sight go through a series of physical and psychological difficulties. The strategies that people with visual impairment use can also cause problems for people with sight. A guideline to promote understanding between people with visual impairment and people with sight is proposed in this paper to help industrial designers who are often working with individualized users to provide customized solutions, which can promote the interaction, communication, and understanding between both groups. The usage of this guideline has been illustrated by the example design implementations.

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Chapter 1 Introduction

1.1 Problem statement

Since the beginning of the 20th century more attention has been paid to people with severe visual impairments in areas such as living problems, mobility orientation, transportation, social life, and others, starting with the state of New York making education compulsory for blind students in 1911, to the U.S. Congress passing the Aid to the Blind Rehabilitation Program in 1935, to Lions Clubs International launching the SightFirst program in 1989, to all the new treatments thanks to new technology (Copp, n.d.). Organizations have been established for helping people with severe visual impairments, which include people who are legally blind and considered to have low vision (which will be referred as the people with visual impairment for the rest of this paper), to live better by training them to orient themselves in unfamiliar spaces, managing their lives, and offering more job opportunities. Accepting the attention and help of these organizations can improve the situations of people with severe visual impairments. Some of these organizations include Lighthouse for the Blind, The Torch Trust and The New Beacon.

No one can deny that when a person starts losing sight or has congenital blindness, that frustration and depression can have negative effects on life if he or she can't get help from other people. Family members and friends are usually the first option that person

will turn to. But most people don't really know that family members will also go through the depression phase with their family member who has visual impairment. A great deal of research and practice has been devoted to exploring how people who are visually impaired should adapt to life without sight. However, most families don't get the training or assistance to teach them how to get along with someone who has lost vision (Bambara et al., 2009; SSMR, 2009).

Living with a person who has severe visual impairment is a new experience for people, especially for the family when their loved one recently has been diagnosed with visual disability and starts losing sight or has been through some trauma and then suddenly loses sight. How to adapt to this new situation is a big problem for both sides. Complete training processes for people with visual impairment from indoor to outdoor have been taught and proven for years. But people who live with people with visual impairment often don't know what they can do to help those with visual impairment to live better and easier. Sometimes, family members and friends overprotect people with visual impairment by limiting their abilities, which weakens their independence and self-confidence.

With the growth of the world-wide population, people living longer, and the increase of the elderly population, there will be more and more people suffering from blindness and severe visual impairments: the report from the U. S, Bureau of the Census showed that the number of people aged 65 or above would reach 70 million by 2030 from 30 million in 2002 (Duffy, 2002). This also results in more family and friends struggling to find better ways to live together people who have visual impairments. In this context, the number of families in need of help and support is expected to increase the growing

demand for products designed for families and their living environments affected by visual impairments.

1.2 Need for this study

For everyone living under the same roof, good communication, not only verbally but physically, is the best support for each other. Home should be a self-sufficient, comfortable zone for everyone. However, although people with visual impairment may have been trained to adjust to living situations by some organizations, there are still many difficulties for sighted people and people who are visually impaired living together in a household.

In the initial stages of loss of vision, people will go through a very complicated stage of psychological change, and they have to experience the same world in a new way. Fortunately, there are many strategies to make the house safer for people with visual impairment, for example, using color coding or buttons for helping them to distinguish objects more easily, such as buttons on the washing machine and oven. But finding things is still a big problem for them, not only because of losing sight and the similarity of different items, but also because sighted people forget about putting things back in the same place some of the time. Asking for help often can make a person with visual impairment feel embarrassed for bothering sighted people and potentially angry for not being able to do it by themselves. It is important to teach people with visual impairments to be more independent and let sighted people to focus less on protective actions (SSMR, 2009).

For sighted people in the house, there are more problems that researchers and designers have never considered before. First, living with and assisting a person with visual impairment brings a lot of pressure to people who are sighted. Often due to their lack of understanding of the condition of people with visual impairments, the person with sight tends to overprotect and sometimes restricts the movements of visually impaired people, which can be frustrating for both (Cimarolli & Boerner, 2005). Also getting used to new living habits required for both is a very time-consuming thing, sometimes requiring interruptions for the person with sight to help the person with visual impairment complete tasks. What's more, some strategies used to help people with visual impairment to distinguish things or protect them from being hurt can cause inconvenience for sighted people and ruin the overall design style of the house.

Those problems will be described in detail in the subsequent literature review. However, there is another important thing to consider. People who are visually impaired have different levels of visual impairment and it varies in severity. Other factors, such as self-rated health, functional vision, and perceived support quality from family members and friends also have impact on the satisfaction of life for a person who is visually impaired (Reinhardt, 1996). Approaching this issue from a human-centered viewpoint suggests the need of understanding the situations and conditions of both groups, visually impaired and sighted people, that live together. This design research should consider the inclusivity of both groups' needs and barriers, then create a better solution that promotes better cohabitation.

1.3 Purpose of the study

The purpose of this study is to help the industrial designer who is often working with individualized users to provide customized solutions to have a better understanding of their user groups and generate a guideline that can help them to design a solution which can be customized and promote communication between their users. This study includes the following goals:

- Understand the physical and psychological changes during stages of losing vision.
- Recognize the needs of people who are visually impaired and who are sighted and the relationships between different user groups.
- Explore strategies and theories designed for people who are visually impaired to live better.
- Develop recommendations for organizing home spaces.
- Investigate the elements that can promote communications by using a design method to build habits.
- Generate a guideline.
- Design products to demonstrate the guideline.

1.4 Definitions of Terms

- **Blind or Legally Blind** - Visual impairments that are not correctable with spectacles, contact lenses, or surgical intervention and that interfere with normal everyday functioning（Mehr, 1975, p. 254).

- **Emotional support** - Affective or social support that provides encouragement or comfort during difficult times (Bambara et al. 2009, p3).
- **Instrumental support** – Persons or objects that provide assistance with tasks of everyday living (Bambara et al. 2009, p3).
- **Low vision** - People whose vision can be corrected to "between 20/40 and 20/200 with conventional prescription lenses" or have a restricted field of vision less than 20 degrees wide ("What is") (see Figure 1.1).

Figure 1.1 Vision 20/40 and vision 20/200 (Adapted from "Symptoms of", n.d.)

- —**Mental Mapping -** Acquiring proficiency in the process of things happening and the logic of handling things (Salisbury & Laconsay, 2020).
- —Product Semantics - "The study of the symbolic qualities of man-made forms in the context of their use and the application of this knowledge to industrial design" ("What is", 2017). These include environmental context, memory, operation, process, and ritual of use (Lin, 2011).

1.5 Assumptions

This study was conducted based on the following assumptions:

- All the theories, results, methods, and statistics found during this research are valid.
- Both people who are visually impaired and people who are sighted who live in the same house are willing to improve their space and communicate their personal needs.
- The issue of communication between different groups could be resolved by reasonable design.

1.6 Scopes and limits

This study will introduce some background of the living conditions for both people who are visually impaired and people who are sighted that live together and the problems they face. This thesis will create a guideline for industrial designers to develop better cohabitation between people who are sighted and those who are visually impaired and build awareness of how spatial organization can improve the way they live together.

All academic literature material is selectively reviewed towards the potential effectiveness of design practices that are implemented in the guidelines of building awareness of organization. This thesis only considers people who only have visual impairments and don’t have any other co-existing disabilities.

1.7 Anticipated Outcome

The primary outcome of this study provides the direction for industrial designers to know where to start to understand and empathize with their users and use the strategies to apply to their solutions based on their research to promote the cohabitation between people with visual impairment and people with sight. By using this guideline, designers can customize a solution for the specific family, or create a solution to be mass-produced if it works for similar situations for several families.

Chapter 2 Literature Review

Towards the goal to provide guidelines for designers to develop better living arrangements between people who are sighted and those who are visually impaired, this chapter lays a foundation by investigating and synthesizing current literature in the following areas:

1. People with visual impairments such as low vision and blindness
2. Sighted helpmates/caregivers of people with visual impairment
3. Living arrangements for people with visual impairment
4. Theories and strategies of managing living environments
5. Elements of products that promote the understanding and enhance collaboration between people with and without visual impairments

2.1 People with visual impairments such as low vision and blindness

In this paper, the author will use people with visual impairment to describe the population of people who have low vision or blindness.

2.1.1 Nuances of low vision and blindness

From a data point of view, in America in 2016, there were 7,675,600 people with visual disabilities (“Blindness statistics”, 2019). That means there are a lot of families

needing and expecting more support from all kinds of sources in order to cohabit with visually impaired family members.

Contrary to popular belief of what low vision and blindness mean, most people with visual impairments can perceive light, colors, and shapes of objects, and only 18 percent of people who are blind actually can't perceive anything ("What Do", 2016). Those impairments which cause low vision or blindness can lead to issues such as:

- **Partial loss of visual field:** Describes people who can only see objects in a certain scope. This type of vision loss can be caused by diabetic retinopathy, glaucoma, macular degeneration and others (Duffy, 2002). Two typical conditions of partial loss of visual field are *central vision loss* and *peripheral vision loss*, which is also called tunnel vision. 39% of people who are visually impaired have central vision loss (Wolffsohn & Cochrane, 2000). A person experiencing tunnel vision may have relatively normal vision (or not), but only within a certain radius, typically within a cone of less than 10 degrees (Helmenstine, 2020).

- **Decrease or increase of lighting requirements**: This applies when people have night blindness, high sensitivity to glare, difficulty in light-dark adaptation, high brightness requirements and so on. Night blindness describes the lack of ability to see objects in a dim environment. High sensitivity to glare creates a blinding effect. Difficulty in light-dark adaptation happens when abrupt lighting transitions are hard for people to adjust to (Duffy, 2002). High brightness requirements describe the need for greater brightness of mainstream products and environments.

Some of the symptoms can cause people to be unable to see clearly (Fogle-Hatch, Nicoli & Winiecki, 2020). This type of vision change can be caused by vitamin deficiencies, aging, and others.

- **Hazy vision**: Represents overall blurring and haziness of vision, which can cause low sensitivity of contrast, depth perception, or being unable to focus close up, as well as other conditions. This type of vision change can be caused by aging, cataracts, diabetic retinopathy and others (Duffy, 2002).

- **Light Perception**: Impacts a person's ability to form clear images, but they can tell when the lights are on or off (Helmenstine, 2020).

- **Decreased color perception**: Describes a person's difficulty in distinguishing colors. This type of vision change can be caused by a defective chromosome (color blindness), medical treatments, cataracts, diabetic retinopathy, macular degeneration, and others (O'Connell, 2019).

- **Distorted vision**: The shapes of objects are hard to distinguish. This type of vision change can be caused by stroke, severe trauma, and others (Duffy, 2002).

- **Fully Blind**: A person may be able to see large objects and people, but they are out of focus (Helmenstine, 2020).

- Other visual impairments can be caused by retinal detachment, brain damage, and others (Duffy, 2002).

Age is also a big influence factor in visual impairment. People over 65 accounted for 52.6% of the total number of people who are visually impaired in America ("Blindness statistics", 2019). Nearly 3/4 of new cases of visual disabilities occur in the over age 65 group (Duffy, 2002). Age-related data on visual disability shows most common causes of visual disabilities are macular degeneration, retina, diabetes, glaucoma, and cataracts (Ellwein et al., 1994; Zuckerman, 2004). Accidental vision loss accounts only for 15% of adult vision loss and 8% of children's vision loss (Zuckerman, 2004).

Since chronic diseases are the main cause of visual impairment, the vision of most patients declines slowly and gradually. Only about 30 percent lose most of their vision in a short period of time (Bambara et al. 2009). During the period of losing sight, there will be some specific problems that are hard for people with low vision or people who are blind to handle (Bambara et al. 2009) For instance, mainstream products, such as word indicators, remotes and so on, can't help people who are blind to be more independent which can cause low self-esteem and depression to happen. For people with low vision, the main difficulty is reading tiny letters, such as in books or on television remotes (Van Rens, Chmielowski & Lemmens, 1991). Additional challenges will be discussed in the next section.

Using this adaption stage when a person is losing vision to help all the family members, including roommates, to get used to the change is a key point of support.

2.1.2 Senses other than vision of people with visual impairment

Other than vision, people with visual impairment use the senses of touch, auditory, smell and taste senses to "see" the world. People with visual impairment perceive touch

faster than people with sight, especially for people who are blind since birth and with early onset blindness (Bhattacharjee, Amanda, Lisak, Vargas & Goldreich, 2010).

Regarding auditory and olfactory senses, visual impairments don't have overall effects on them. However, though there are no group differences of these two senses, heterogeneity does happen to different individuals. One study showed that early blind people have better auditory recognition then people with sight. Another study showed that people with visual impairment have a better recognition on pitch discrimination and pitch/timbre categorization tasks. Some people who are visually impaired have even mastered the skill of echolocation to perceive the information from the outside world (Borreli, 2016). Some people with visual impairment identify more odors than the sighted in free identification (Cornell, Arshamian, Nilsson & Larsson, 2016; Sorokowska, Sorokowski, Karwowski, Larsson & Hummel, 2019). Taste will not be discussed in this paper.

2.1.3 About Braille

Similar to sign language, Braille has been seen as an irreplaceable and modern way for literacy, which is a very useful tool for people with visual impairments ("Braille"). However, contrary to expectation, over 90% of people who are legally blind in the United States can't read Braille (the National Federation of the Blind Jernigan Institute, 2009). There are three important factors to consider for people to learn Braille: age, motivation and reading skills of the learner. According to the Neuroscientist Colin Gerber, their learning time varies depends on different people and usually requires

around 500 hours of studying for an adult. Also, as the age grows, it's harder for people over 14 to learn a new language and take longer to master ("How long", n.d.).

2.1.4 Challenges & needs of people with visual impairments

At the beginning stage of losing sight, a psychological crisis is frequently the first problem people face. Some people refuse to come to terms with the fact that their eye condition is deteriorating, which makes it harder for them use the assistance they can get (SSMR, 2009). People who have suddenly lost sight and can't accept their impairments tend to have more difficulties when, for example, other people move objects around in the house (SSMR, 2009). There are a lot of key changes happening in their life with little to no time for them to make adjustments. Within their indoor environment, changes can include a personal inability to complete household tasks or see the words on different products, having trouble communicating with people due to lack of non-verbal interaction, or restrictions on their mobility by other people. Psychologically, these difficulties can cause people to lose hope and become depressed (SSMR, 2009).

Additionally, because they have lost one of their senses, fear of not having enough of information can cause people with visual impairments to have unexpected reactions. For instance, Charles Bonnet Syndrome can be triggered by unexpected reactions due to the fear (SSMR, 2009). Charles Bonnet Syndrome is a disease which can cause visual hallucinations and usually happens due to the vision loss. The hallucinations can make people distressed and have a negative impact on the quality of their lives (Pelak, 2019).

In the process of getting used to their new visual impairment, other problems emerge for visually impaired people. One of the biggest challenges is that they lack independence because of their vision-related functional limitations. There are a few common problems that happen to most people. First, when people need to read labels or try to find out the current conditions, for example, reading the information on the AC controller and finding out the temperature, the most common situations when they need to ask people who are sighted for help, they may struggle (Hudec & Smutny, 2017). Second, the most challenging household tasks were preparing meals (with a high requirement of learning how to cook) and house cleaning, which would take a longer time than before (SSMR, 2009). The last and most difficult issue people who are visually impaired had according to a study done by the University of Surrey was if the house was not tidy and family members did not put things back to where they normally were, even a few inches away, it would be extremely hard for people with visual impairment to find the items (Cimarolli & Boerner, 2005; SSMR, 2009; Branham & Kane, 2015). For the people who are sighted who they live with, it's hard to know if they put things back to the exact same spot (Kennedy, 1983). The same spot usually represents the general place people put the objects. But according to the blind youtuber Tommy Edison, even when his friend put the popcorn bowl back to the same place, but a few inches away, it made Tommy upset the bowl (The Tommy Edison Experience, 2011).

Even though people who are losing their sight sometimes have the desire for assistance, the urge for independence often makes them shy away from asking for help (Brennan et al., 2001). A study from University of Surrey shows that, "the optimum role

for support appeared to be encouragement to the person with sight loss to do things, rather than doing everything for them" (SSMR, 2009 p.85).

2.1.5 Importance of family members and friends' support

Support from the family is particularly important at the initial stage when a person starts losing sight. Small tasks (e.g. cooking and cleaning) can be challenging for people who are visually impaired to accomplish. The support from the family will be a great help in this respect (SSMR, 2009). The more family members know about the visual impairment, the more they can help their visually impaired family member. Small consideration and help from the family can greatly reduce the danger around them and can provide them with the convenience of life (SSMR, 2009). It will also lower the distress level and other negative health outcomes. When the family is more flexible, adaptive, cohesive, supportive, and high functioning, people with visual impairment are more accepting of the current situation. What's more, instrumental support from their family is especially important for people who are visually impaired who also suffer from other neurocognitive deficits (Bambara et al. 2009).

Because of their visual impairment, people sometimes start shutting down, staying inside, and cutting down on social activities. But in fact, support from a friend is more important as the person adjusts to socio-emotional concerns and internal changes (Reinhardt et al. 2009) and can help people with visual impairment to accept their vision loss (Reinhardt et al. 2009 & Reinhardt, 1996). Based on some visually impaired people's experience, the adaption stage is in direct proportion to the age, which means the older a person with visual impairments gets, the longer it takes for the person to adapt (75).

Social activities help to relieve depression, which happens often in people who are visually impaired (SSMR, 2009).

This also applies to roommates who live with a person who is visually impaired. Sometimes a person who is visually impaired needs the assistance from their housemates to maintain control of their environment (Branham & Kane, 2015).

2.2 Sighted helpmates/caregivers of people with visual impairments

A study done by Jennifer K. Bambara and colleagues (2009) about Family Functioning and Low Vision showed that both family members and friends have a great impact on the lives of people who are visually impaired. Family and friends who live with people who are visually impaired frequently have more intimate relationships with them than other people in their life. They often have the person's medical history and offer instrumental and emotional support.

However, taking care of people with disabilities is not an easy thing. There are two different attitudes towards that. Due to lack of information and sources, many people have negative attitudes and consider it as a burden. Some people are likely to use the adverse situation as an opportunity to strengthen the bonds between families (Lupón i Bas, 2015).

By understanding more of the situations that people who are sighted are in, it will be easier for designers to focus on the pain point of the problem.

2.2.1 Objective issues people who are sighted have

To make most activities in the house environment accessible for people who are visually impaired, assistance from family or friends is essential (Kennedy, 1983). This means, while people who are visually impaired seek help, activities that disturb their family members are inevitable and require their time, energy, and money (Bambara et al. 2009). In cases of children who are visually impaired, sighted parents experience a range of psychological problems, including self-doubt that giving constant care demands (Lupón i Bas, 2015). Difficult and complex situations make it hard for family members to find a balance between providing help and maximizing the security and independence of the individual (Bambara et al. 2009).

Multiple studies have shown that there are obvious deficiencies in the training of family members of people who are visually impaired, especially for the elderly group (Lupón i Bas, 2015 & SSMR, 2009). Most family members can only offer instrumental support (Cimarolli & Boerner, 2005).

What's more, the strategies that people who are visually impaired use can cause problems and disruptions to daily activities of people who are sighted (Branham & Kane, 2015). For instance, tactile labels can cover the underlying visual labels to cause inconvenience to people who are sighted (the Braille stickers a visually impaired person put on the microwave buttons can make it harder for people who are sighted to see the information on the screen) (Branham & Kane, 2015).

2.2.2 Subjective issues people who are sighted have

2.2.2.1 Psychological and physical stress

When one of the family members suffers from the pain or inconvenience of losing vision, the rest of the family members will also go through a series of psychological changes like incredulity, denial, anger, pain, sadness, depression, emptiness, reassessment, acceptance, stress, and sleep insufficiency (Bambara et al. 2009; Lupón i Bas, 2015). One study showed that 35.4% of caregivers might suffer from depression and people who provide close supervision over 2.5 hours per day also had increased potential of depression (Bambara et al., 2009; Braich et al., 2016). People with visual impairments who are ageing often need more assistance for daily activities as underlying diseases advance (Bambara et al. 2009).

For people who are sighted, another challenge they face is to balance their own lives with the needs they provide to people who are visually impaired (Bambara et al. 2009; Lupón i Bas, 2015). Loss of work time to help people who are visually impaired can also result in the loss of wages. What's more, the need to purchase related equipment and rehabilitation services can cause households to face unexpected financial difficulties (Bambara et al. 2009).

2.2.2.2 Problems of over-protectiveness

One phenomenon that is prevalent in the caregiver community is unnecessary help, which includes over-protection, excessive praise for accomplishments and attempts to eliminate visually impaired people's activities. The main reason for over-protection is that people who are sighted worry about the safety of people with visual impairment.

Simultaneously, unnecessary help is also considered negative support which impedes the realization of the instrumental goals (Cimarolli & Boerner, 2005).

People who are sighted may not understand that people who are visually impaired also need personal independence to some extent (Cimarolli & Boerner, 2005), such as restricting activities in geographic range, reducing house chores like cooking, and others when people with visual impairment are able to learn how to handle those situations (Brennan et al., 2001).

2.2.2.3 Needs of sighted helpmates/caregivers of people with visual impairment

Out of fear of the unknown, the first and the most important thing people who are sighted need is more information of the conditions impacting people with visual impairment, the consequences and the services they can seek (Lupón i Bas, 2015).

Another common dilemma for people who are sighted is how to regain control of their lives while they spend a lot of time, money, and energy for supporting people with visual impairment. If people who are sighted can get more instrumental support through products or human services, they will have more spare time for themselves, hanging out with friends, enjoying leisure time, and keeping the family together and stronger (Lupón i Bas, 2015).

2.3 Living arrangements for people with visual impairment

2.3.1 Who people with visual impairment live with and daily activities of people with visual impairment

When people start losing sight, getting used to the surroundings is not an easy thing. Based on a survey (Wolffsohn & Cochrane, 2000), nearly half of patients with low vision claimed that their functional status and quality of life have been greatly negatively affected by impaired vision since their eye condition was diagnosed. For visually impaired people, one-quarter of them who are over 30 years old have moderate difficulties in a familiar environment, and that number went down for people who are under 30 years old (Van Rens, Chmielowski & Lemmens, 1991). But for people who are blind, more than half (52 percent) of them have difficulty in daily 'instrumental' activities (Zuckerman, 2004).

People who are visually impaired primarily are generally living with someone. In the age groups 0 to 29 and 30-59, 25% or fewer live alone. In the age group over 60 more people live alone (~46%) while 33% live with a spouse and the remainder with someone else (see Figure. 2.1.2) (Wolffsohn & Cochrane 1999). Zuckerman (2004) reported that among people who are blind, around four fifths (80%) live with other people with an even greater percentage in the over 75 age group.

Breakdown of living status by age.

Age (yr)	Alone (%)	With Spouse (%)	With Family (%)	Institutional Home (%)	Other (%)
0–29	20.8	0.0	70.8	4.2	4.2
30–59	25.0	37.5	27.1	2.1	6.3
60+	46.5	33.4	11.6	5.0	2.1

Figure 2.1 Breakdown of living status by age (Adapted from Wolffsohn & Cochrane, 1999, p.5)

These statistics do not represent all cases of people with visual impairment. Aymeric Vildieu (2021), the author's committee member who is visually impaired and who lives by himself, said that he is used to living in the blind world, so dealing with and finding the objects in his living space is not a problem to him.

So what problems are people who are visually impaired facing in daily activities which can be solved by design?

The common assistance people with visual impairment need are in reading (from a newspaper, screen, or computer), operating all household equipment including the heating system, orientation in the colors of clothes, and recognizing objects (Hudec & Smutny, 2017).

Starke, Golubova, Crossland & Wolffsohn (2020) conducted a real-life recording study of people with low vision (see Figure 2.3). From the tasks identified in their recordings from daily living, the most used words were 'read' (49%), 'find' (8%), 'identify' (6%), 'bus' (5%), 'operation' (4%), 'label' (3%), and 'TV' (3%). They reported that for people with low vision, most choose to use amplification equipment in relation to 'read' and 'TV'. People who are blind rely more on Braille and hearing. 'Bus' is outside of the living environment, so it will not be discussed in this study. Based on this study, the main problems people who are visually impaired have in their living environment are 'find', 'identify', 'operation' and 'label'. 59% of their participants mentioned all these tasks: finding something on a crowded shelf; reading package labels; and using appliance dials, buttons, and remotes. Consideration of these areas can help designers to see what type of help the target group may need.

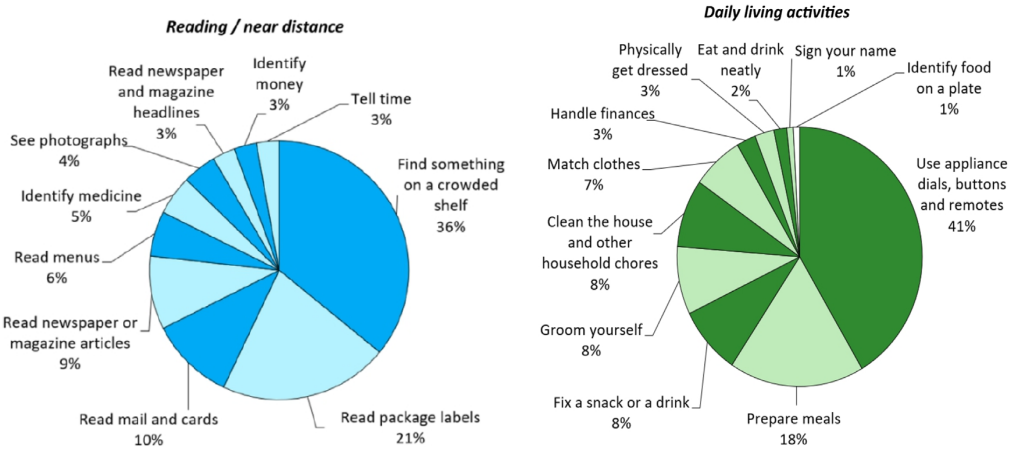


Figure 2.2 Main problems people who are visually impaired have in their living environment (Adapted from Starke, Golubova, Crossland & Wolffsohn, 2020, p.9)

2.3.2 Understanding the effects of living arrangements of different combinations of people who are visually impaired and people who are sighted.

As previously discussed, there are some common problems people who are visually impaired all go through; however, the visual status of the people in the living arrangements can pose some different requirements. This segment identifies several typical ways people live together and some of the strategies to manage those arrangements that were found in this literature review.

2.3.2.1 People who are visually impaired who have family and friends come visit

An adult with visual impairment who lives alone really doesn't fit the target group in this study. Figure 2.4 illustrates this group. According to the blind committee member,

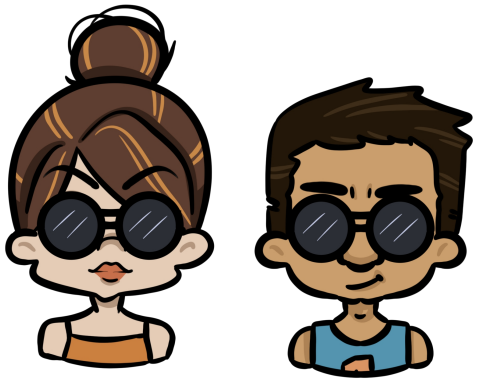


Figure 2.3 Adults who are blind and who live alone

Aymeric Vildieu, who lives by himself, said, when he was used to living in the blind world, even if the house a little disorganized; as long as no one moves his items, he has no problem of dealing and finding the objects in his living space.

However, things can be different when the person with visual impairment has visitors to join them; the main thing he/she needs to worry about is that visitors can move their belongings and possibly not put things back to the same place. For example, in the book *On Sight and Insight: A Journey into The World of Blindness*, the author John M. Hull (1997), who is legally blind, mentioned that things were out of his control when relatives came to visit and put unfamiliar objects everywhere during Christmas.

2.3.2.2 One person with visual impairment in an adult couple

A big concern in married couple life is overprotecting actions from the partner who is sighted and that may cause physical and psychological overload (refer to 2.2.1.2.1) to their loved one (represented by Figure 2.5). One goal is for the partner who is visually impaired to be more independent on the things like use or maintenance of small appliances (kettles, microwaves, vacuum cleaners), and basic operation of larger appliances (washing machine and stove) or controlling the heating or cooling (Hudec & Smutny, 2017, p10).

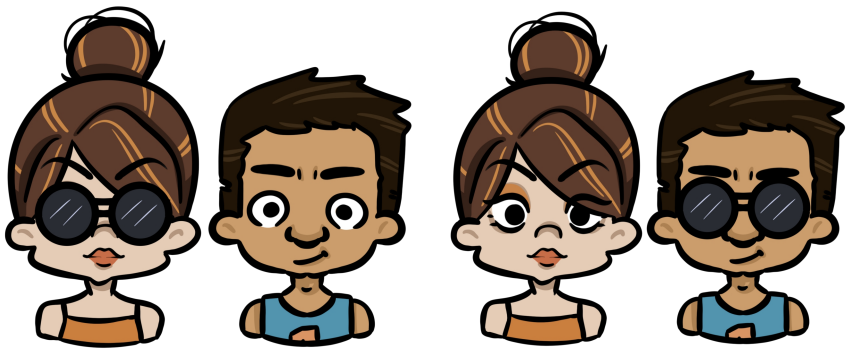


Figure 2.4 One person who is visually impaired in an adult couple

2.3.2.3 Parents who are sighted and children with visual impairments

When parents get the diagnosis of their child's impairment, mentally they will go through a series of psychological changes: "increased anxiety, lower self-esteem, emotional maladjustment, passivity and loss of locus of control" (Sola-Carmona et al., 2016, p. 2). From the family's physical level, in most cases, a mother will put most of her attention on taking care of the child who is visually impaired and neglect the needs of other family members. At the social level, the rest of the family will have to work harder to maintain the relationship like before because of the feelings of shame or excessive responsibility (Sola-Carmona et al., 2016). A study of quality of lives of parents who are sighted showed that there is not enough support and guidance to teach parents about dealing with their children who are visually impaired (Lupón i Bas, 2015).

Another problem is many parents do not know how to communicate with and describe objects to their children who are visually impaired. A study of communication between parents and children who are visually impaired done by Moore and McConachie (1994) showed that parents of children who are visually impaired tend to use imperative rather than declarative statements, and seldom describe information about the function

and properties of objects to their children. Descriptive information about the environment, such as the feel, sound, smell, or shape of an object and others, can enhance the consistency of children's understanding of language and environment and promote language and other senses development. As children who are visually impaired become more familiar with the appropriate environment, their autonomy will be greatly improved (Sola-Carmona et al., 2016). Figure 2.6 illustrates this living situation.

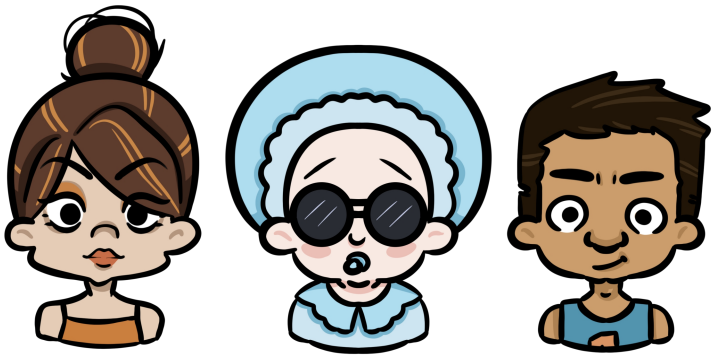


Figure 2.5 Children who are visually impaired with parents who are sighted.

There are several aspects that parents can encourage the children to accomplish in daily life: “in obtaining and reading learning materials; in writing documents; in using household appliances; in playing and in their hobbies; in orientation in the environment (weather forecast)” (Hudec & Smutny, 2017, p. 10).

To help children who are visually impaired to build confidence and become self-reliant, parents need to train them to exercise and use their other senses. Consider the example of the white cane children use that has a metal tip which can create great auditory feedback to tell cane users what they are touching (Chamberlain, 2017; Hartle, 2013).

One way to help children who are visually impaired remember objects more quickly is to acquire proficiency in the process of things happening and the logic of handling things, which is also called mental mapping (Salisbury & Laconsay, 2020). They need to remember the position of other objects relative to the main object. For example, according to this logic if pot-holder gloves are expected to be used to remove things baking in the oven, then they should be in the drawer next to the oven.

2.3.2.4 Children who are sighted and parent with visual impairments

When talking about parents who are visually impaired, of course people first will think that taking care of children who are sighted can be a big challenge for them (see Figure 2.7). But, unexpectedly, the lack of sight does not really restrict most daily activities between parent and child (Collis & Bryant, 1981). There are a few strategies that parents who are visually impaired usually use to supervise their children.

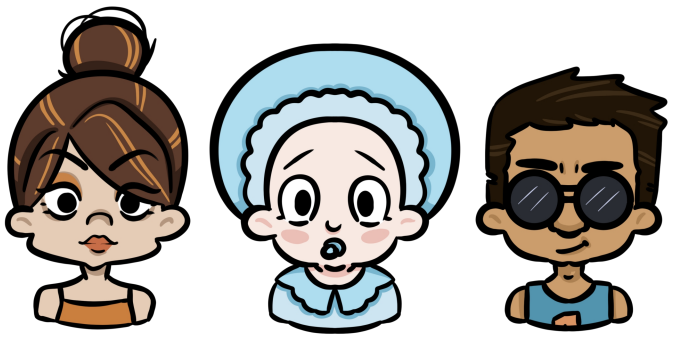


Figure 2.6 Sighted children living with a visually impaired adult

For monitoring the children at home, the occupation and location of the child are the most important information parents want (Hudec & Smutny, 2017). Sounds made by objects is one of the best ways to get the information (Collis et al. 1981). To locate the little children, parents often tie bells on their shoes (“What is” & Helmenstine, 2020).

However, using hearing to identify dangers to a child cannot be enough (Hudec & Smutny, 2017). So, childproofing the house is another subsidiary strategy that visually impaired parents do to protect kids (Helmenstine, 2020).

Although parents with visual disabilities can take care of their children without any harm, there is a relatively common phenomenon that happens to children, but parents rarely pay attention to it. The children who are sighted can wonder if they are just 'a pair of eyes' for their parent (Collis & Bryant, 1981). Compared to parents who are sighted, parents who are visually impaired may ask more blindness-linked requests of their children and that kind of unconscious behavior can cause hostile feelings from children which turns them against their parents (Deshen & Deshen, 1989). When the misunderstandings happen between parents and children, the trust and security of the child can be sabotaged (Deshen & Deshen, 1989). Establishing effective communication and building the awareness of being more independent are the two secrets to improve the situation.

In general, in this combination of families, parents who are visually impaired need to be more independent than they expect. Acknowledging their own disability will help parents manage themselves in the world full of people who are sighted and succeed in getting maximal benefits and attaining status in their homes (Deshen et al. 1989).

2.3.2.5 Person who is ageing with visual impairment living with adult partner, or with their adult children

As Maureen A. Duffy (2002) said in *Making Life More Livable*, "85% to 90% of older persons with these age-related eye disorders have some remaining sight--also

known as ‘low vision’” (p. 10). Age-related eye disorders include cataracts, diabetic retinopathy, glaucoma, macular degeneration, and other diseases, such as stroke, retinal detachment, brain damage or trauma. One study shows that elderly families get less support to assist their relatives who are visually impaired than other families. This study at the University of Surrey showed that this ageing group has tremendous desire to maintain their independence and would not like to seek for assistance, which makes instrumental assistance more significant (SSMR, 2009).

There are two main living situations illustrated in Figure 2.8: a person who is ageing also with visual impairment who is 1) living with a partner/adult who is sighted OR 2) living with their adult children. In the latter case, the person with visual impairment needs to be more independent, as young people need to find a balance between work, life and home care with limited time and energy available for caregiving for a person with visual impairment.

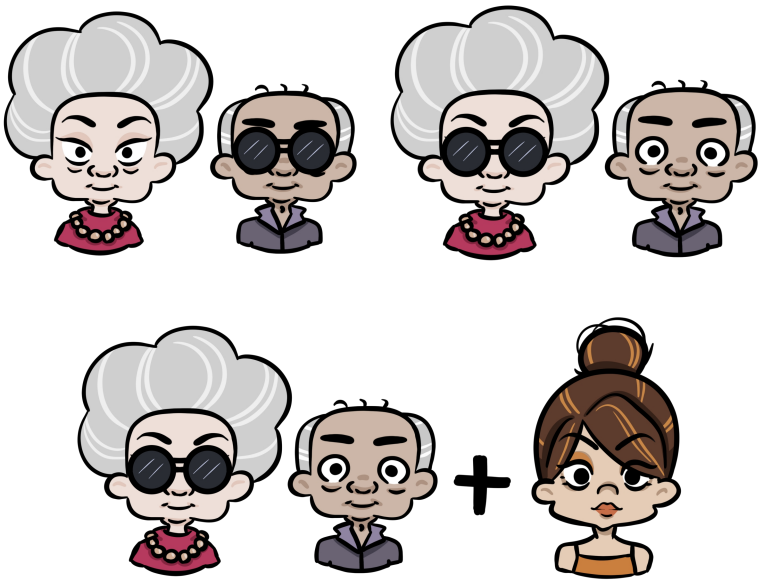


Figure 2.7 Person who is ageing with visual impairment living with adult partner, or with their adult children

There are a few common problems and popular countermeasures for helping ageing life become more livable by making minor changes to furniture and environments according to Duffy (2002, pp. 6-9).:

1. **Decreased color perception** - Use more contrasting colors instead of close colors to emphasize the differences between items.
2. **Reduced contrast sensitivity** - Use contrast to let things pop out in the plain surrounding.
3. **Decreased depth perception** - Use light, contrast and color or other options to create close attention.
4. **Increased sensitivity to glare -** Combine high brightness environment and low reflective material to reduce glare.
5. **Decreased light-dark adaptation** - Use lights on specific items.
6. **Decreased ability to focus close up** – Use amplifying equipment.
7. **Increased lighting requirements** – Add lighting equipment.

2.3.2.6 Person with visual impairment living with a non-family member (roommate)

This represents a small proportion of the living arrangements described. According to one study done by Branham and Kane (2015), because housemates sometimes do not realize how important organization is for people who are visually impaired, they may undermine an organization scheme. Because of their differing needs and abilities, it will take time for housemates and people who are visually impaired to collaborate on effective spatial organizations that works for them together (Branham & Kane, 2015).

2.4 Theories and strategies of managing living environments

It has been suggested that correct coping strategies can successfully adjust the levels of anxiety and stress between people who are visually impaired and people who are sighted (Lupón i Bas, 2015).

To help an individual who is visually impaired to improve his or her self-control and independence, a person who is sighted should avoid taking over all the household tasks. Small aid can be good for people who are visually impaired (SSMR, 2009).

Moreover, strategies also need to be applied variously, depending on the family, such as seeking or using rehabilitation services, seeking information or advice, using other senses or memory, modifying tasks systematically and, restricting activities (Brennan, et al., 2001).

2.4.1 Key factors of indoor living environment (physical environment):

Lighting, reducing glare

According to people with visual impairment's condition, lights need to be increased or reduced for them to read and socialize. It also has to be aimed at the focus point with easy switch on and off control. Also, shiny surfaces, such as polished floors, should be reduced (Daniel, 2018; "How to", 2021).

Open walkways

Furniture and objects need to be arranged to create an opening space for people with visual impairment to move easily and avoid injury (Daniel, 2018; "How to", 2021).

Organizing & labeling objects

Keeping the living environment organized can help people to find the objects they need, which can also eliminate obstacles and reduce frustration while doing daily activities. Always place the objects in the same spot. Label objects in the house for easy access to the items they need. Use sense of touch to navigate the person with visual impairments (Daniel, 2018; “How to”, 2021).

Eliminating hazards

Remove hazards and obstacles as possible. Fix all damage in the house to avoid accidents, such as loose carpet and broken handrails. Mark out the important controls, such as the thermostat (Daniel, 2018; “How to”, 2021).

Creating color contrasts

Solid bright colors are usually easier to see. Less upholstery and pattern. Place light color objects around dark backgrounds (Daniel, 2018). Use different color schemes in different rooms (“How to”, 2021).

Bathroom

A larger bathroom will be a plus. The toilet should be placed at a convenient place. Avoid shiny material in the bathroom (Bharat, 2014).

Kitchen

Always keep everything in its original place (Daniel, 2018), and use different colored or Braille labels on the appliances (Bharat, 2014).

2.4.2 Organization of the indoor living environment (physical environment)

As previously discussed, the living environment has an impact on people who are visually impaired in the adjustment stage of vision loss. For some people who just lost their vision, to relieve concerns about their safety and quality of life, they may choose to relocate or seek other living arrangements (Duffy, 2002).

New arrangements of living environments can be set up at the accepting stage (accepting, adjusting, normalizing). A clean room helps people to confront the problems they are facing (Kondo, 2014). Rearrangement can also give people a fresh view to look at their situation and helps people who are visually impaired to memorize locations for future access (Branham & Kane, 2015). However, a common incorrect expectation of people who are sighted is that a smooth and open area is good for people with visual impairment. On the contrary, an open space without orientating signals is a disaster for people who are visually impaired (Hull, 1997). Therefore, the living spaces need to be organized in a way that avoids being overly minimalistic or cluttered.

For organizing indoor spaces, some of Kondo's suggestions may be valuable to help people with different visual abilities to arrange their places. According to her theory, rearrangement is to clean up the space for locating items as quickly as possible, in other words, sort belongings into those which can spark joy and throw away the clutter (Duffy, 2002; Kondo, 2014).

The second thing is to make easy access for people with visual impairment to find what they need. Because of their sight limitations, people who are visually impaired have difficulty finding an item which is not in the original space (Branham & Kane, 2015). Reorganization and defining storage spaces are what people who share the living

environment need to do together. Storage spaces need to be identified with items sorted by category. The goal is to help all the people who live in the space to adjust their actions to form a smooth traffic flow in the house without getting into the habit of dispersing stuff all over the house (Kondo, 2014).

Other recommendations to help people detail the living space rearrangements identified in this literature review include the following:

- Use soft things to cover sharp edges and corners (Duffy, 2002).
- Items can be placed in accordance with the law of activity line or living habit. For instance, arrange medications in different rooms according to the time of day (such as breakfast, bedtime, and others) (Duffy, 2002).
- Use furniture or other things to differentiate living spaces (Duffy, 2002).
- Rugs and carpets are not suggested to be applied in the house unless they can be stuck tightly on the floor (Duffy, 2002 & Riazi et al. 2012).
- Do an environmental assessment with the person with visual impairment; walk through the entire house to familiarize all with where things are placed (Duffy, 2002).
- Create high contrast to make objects are more conspicuous from the background (Duffy, 2002).
- Consider lighting type: use fluorescent lights to avoid creating shadows and glare spots in the house (Duffy, 2002). Spotlights, portable lights, and lamps can be used as assistant lights in hidden areas such as closet, cupboards, and other places (Riazi, Boon, Bridge & Dain, 2012). Timers and motion sensors are also suggested to be applied on the lights (Riazi et al. 2012).

- Put the most frequently used items in the easiest places to reach for people who are visually impaired (Riazi et al. 2012).
- Good organization skills can reduce the need for labeling and marking items such as cans, seasoning and others (Riazi et al. 2012).

2.4.3 Using other senses to convey information about the environment and things in it

Duffy recommends making full use of other senses to perceive places and objects (2002). Translating visual information from the environment and products to other formations has become a popular way (Branham & Kane, 2015; Guo, 2010). Information presented through different physical forms such as weight, texture and shape, temperature, and sounds can be very useful for people who are visually impaired to receive the messages conveyed by the surrounding environment (Hull, 1997).

This section details other recommendations and strategies related to the senses of hearing, touch, and sight (color vision and lighting) to help people with visual impairment translate information about the environment and products they engage with.

Voice feedback is one of the major strategies for people who are visually impaired to get visual information. For the bottles that have labels on them, such as medicine bottles and seasoning bottles, talking labels allow people who are visually impaired to get easy access to the information ("Parenting without", n.d.). What's more, using a family member's preserved voice can also be a good way to enhance the family bond (Hudec & Smutny, 2017). Amplification equipment is still widely used in daily life (Brennan, Horowitz, Reinhardt, Cimarolli, Benn & Leonard, 2001).

The sense of touch plays a big role in the lives of people who are visually impaired (SSMR, 2009). Tactile feedback also has been applied to a lot of products. Materials can be distinguished by the size difference, shape, material characteristics and surface features (Fogle-Hatch, Nicoli & Winiecki, 2020). In the case of electrical appliances, using Braille is a common solution, although this can be somewhat confusing for people who are sighted (Branham et al. 2015). Raised labels and dots are sometimes used on rotatable switches, such as the switches on stove and microwave, so people with visual impairment can know the switching status. Raised marking materials, such as a Hi-marks 3d marker, maxi-marks, bump dots, or spot'n line pen, to make marks can help people with visual impairment get information through different textures (Duffy, 2002). For picking up small metal pieces like needles and pins, magnets can be a great help (Riazi et al., 2012).

Color coding is also widely used in daily life and can provide positive feedback for some people who are visually impaired (Riazi et al. 2012; SSMR, 2009). Examples of this include the following:

- Paint bright or fluorescent colors, like white, red, yellow, and orange, on sharp edges, such as the steps, entrance rim (Riazi et al., 2012; SSMR, 2009).
- Use contrast color on different products. The colors red, blue, yellow, and green are more recognizable (Riazi et al., 2012).
- Avoid using transparent products (Riazi et al., 2012).

Extra lights can be helpful for people who still have slight sight. Small lamps can be helpful to put on some specific items, for instance, over keyholes to assist people aim

the target and for reading materials, labeling sections is more efficient than enlarging the print (Riazi et al., 2012).

Sound effects can also be used to convey information. For the natural sound effects, smaller rooms can provide calmer, safer and more pleasant feelings for people than bigger rooms. Negative sound effects are not affected by the room size (Tajadura-Jiménez, Larsson, Väljamäe,Västfjäll & Kleiner, 2010).

2.5 Elements of product that promote the understanding and enhance collaboration between people with and without visual impairments

This section introduces elements of the product that can promote the understanding between people (both people who are visually impaired and sighted), and between people and products. In some interactions, such as asking for help to deal with objects, there are actions happening during or after the communication. This requires developing new levels of trust between the parties and reducing negative feelings or stressful conversations caused by the inability to be independent of the person with visual impairment or an overprotective family member. Because different people have different behavioral needs, developing a shared language between them will greatly improve the efficiency of collaboration. Habit development can be essential to helping people who have recently developed visual disabilities as well as the people they live with to successfully navigate their life together. Product semantics can be used to motivate users to new behaviors and form the desired habits.

For people who are visually impaired, two studies showed that if they can accept their shortcomings from a psychological perspective, they will have a higher quality of

life and improvement, including requiring less help from people who are sighted (Tursi & Cochran, 2006; Wolffsohn & Cochrane, 2000). From this point of view, designers can use the physical product semantics to help people who are visually impaired to accept the disability in a more relaxing and stress-free way.

2.5.1 Empathy

Empathic design is a design approach that requires designers to pay attention to user's feeling about the product (Crossley, 2003), which is also the basics of human-centered design (Doorley et al, 2018).

According to the empathy design method (Mortensen, 2020), by using observation, doing interviews or other ways to record details of what happened, analyzing (ask "whats", "hows", "whys") the person's behavior (for example, is the person smiling or frowning) and making guesses about people's motives and emotions by the education designers got, designers can understand users' needs, behaviors, feelings, and reasons for interacting with products in a real-world environment.

Additionally, to have a better understanding of the user's emotional journey and the pain points while the user is using the product, Shin and Thomas (2015) introduced the Emotional Curve (Irrational/Rational) into the empathy phase. Instead of getting the direct result of product's use, the Emotional Curve (Irrational/Rational) can be used to analyze and improve the unknown risks or unexpected delays. Irrational represents "user' s perception about the anticipated use of the product or process of the activity", while rational refers to "the positive/negative experience of the real process, use or activity" (p. 4).

2.5.2 Promoting trust through shared language

When a family member or friend loses sight, it becomes a *fait accompli*. However, according to the study by Tursi and Cochran (2006), *accompli* does not change the nature of behavior and emotions, but beliefs do. Therefore, convincing people who are sighted to trust and believe in instrumental support and use the semantic meaning of the product to change people's minds became a breakthrough in this direction. Evidence also shows that instrumental support can be a great help for releasing stress and other negative health problems (Bambara et al. 2009).

A shared language is more efficient way to relate and solve problems (Brothers, 2005). It's also essential to collaboration, which needs a great deal of mutual respect, tolerance, patience, and a common purpose (Thomas & McDonagh, 2013). One big advantage of shared language is that it can be a positive influence for a group of people, not only between people who are actually speaking.

Shared language can also help people to decrease the communication barrier brought by the translation process (Thomas et al, 2013). It will be easier for people who are sighted to understand what people who are visually impaired need without verbal communication and keep both groups on the same page.

Even more important, shared language is not limited to verbal expression. Spoken words can evoke different forms of memory. In reverse, different understanding or memory forms can be used in a shared language, such as visual, touch and forms beyond verbal, to achieve the shared goal. Moreover, non-verbal interaction between people who are sighted people and people who are visually impaired can also be used to convey affective messages (Chiesa, Galati, & Schmidt, 2015).

Why is a shared language crucial to people who are visually impaired and people who are sighted who live under the same roof? To some extent, people who are visually impaired need to force themselves to form new habits to live in certain spaces because of their visual disabilities. They potentially are unwilling to ask for assistance from sighted helpmates/caregivers for fear of burdening other people (Krishna, Colbry, Black, Balasubramanian, & Panchanathan, 2008). Discovering the whereabouts of belongings they need can be a challenge for people who are visually impaired; however, people who are sighted can usually find what they need in a short time, even though it may not be at the place it should be. The two groups have different levels of organizational need because of their different abilities. What's more, verbal forms of communication may not be expressed in a timely manner when people with visual impairment and helpmates/caregivers are not in the same place due to geographical and spatial inconsistencies. In social situations, more than half of human communication is physical interaction (Knapp, Hall & Horgan, 2013).

2.5.3 Habit development

During the adjustment time of losing vision, due to the new situation people who are visually impaired and the people they live with are facing, they need to develop some new habits to adapt to a new environment.

A habit is formed by repeating the same behavior over and over again. The behavior that drives people to do something should be without consciousness, thinking, and reasoning. People's daily lives are driven by behaviors that have long since become habits and most habits are related to particular products (Lui & Li, 2016). This is one

cornerstone of the entire goal of helping sighted people to have a better understanding of visually impaired people's needs and develop new behaviors into a habit.

To help designers to create products which can encourage people to develop a new habit, there are three crucial factors that help people decide whether to take action or not: motivation, ability and trigger according to the Fogg Behavior Model (Fogg, 2009), shown in Figure 2.8. Motivation represents the degree to which the user wants to perform an action, ability means the difficulty related to the user's ability to perform actions, and a trigger is to activate the action (Fogg, 2009). The last two factors can be achieved through intentional product design.

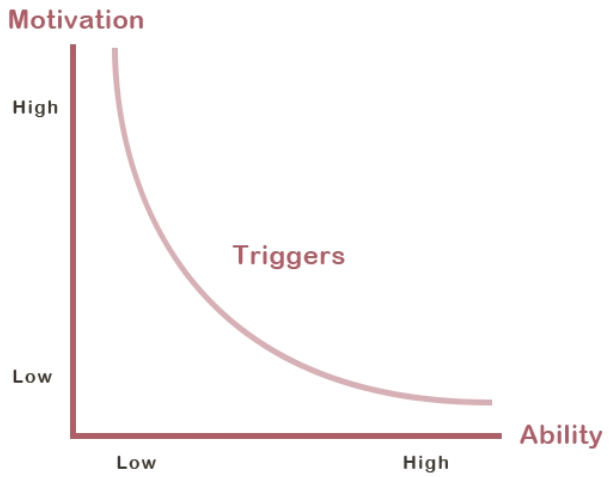


Figure 2.8 Fogg Behavior Model

First, every habit starts with a piece of specific information that tells people what to do, which is the trigger. Triggers fall into two categories: *internal triggers* which are nonrepresentational things like emotion, memory, reflection, heuristics, and association; and *external triggers* which include "check engine light, play video button, mailbox icon, one-click purchase button, etc." (Lui et al., 2016, p. 2). Internal triggers have a bigger

impact on forming habits than external triggers. Moreover, negative emotions, like fear, sadness, and others, that people prefer not to experience also play a more significant role of developing the long-term habits (Lui et al., 2016).

A habit is a subconscious behavior developed from hundreds or thousands of repetitive behaviors. Because of their disabilities, people who are visually impaired have to make themselves more independent in a short time, which is why it's so important to help both the people who are visually impaired and their sighted helpmates/caregivers develop new habits that benefit both of them.

So, the question is how to get people to actively repeat the same behavior? One theory of developing habits is a closed loop of trigger-action-reward mechanism. Lui and Li (2016) combined two models (the Axiomatic Design Theory by Suh and the Hook Model by Nir Eyal), and defined reward as a special sense of accomplishment in meeting the needs of a particular customer. This can be divided into three forms: *reward of tribe, reward of hunt*, and *reward of self*.

Reward of tribe represents the pleasant emotions from the efficient communication, collaboration, and network with other people. *Reward of hunt* refers to exploring desirable resources by themselves. That can be motivation for children who still have a great passion for exploring the world. The last one, *reward of self* means the gratification from solving the problem, completing a task, or improving abilities and others. Based on Lui and Li's theory, self-reinforcing mechanisms can also enhance the time and effort users put into the product, which will create more value to the product and prompt the product to be used more (Lui & Li, 2016).

For a product to help people form a habit, there are several things that need to be included in the design according to Lui and Li's study (2016):

1. Discover the trigger or the negative emotion for the target users to activate the behavior.
2. Conduct the behavior triggered by the visible external information.
3. Give the rewards from the behavior.
4. Investment of time put into that product by the users makes it more valuable.

2.5.4 Product semantics and triggers

Professor M. McCoy from the Cranbrook Academy of Art divided product semantics into five factors: *environmental context, memory, operation, process,* and *ritual of use* (Lin, 2011).

- *Environmental context* suggests that the products' signs should match with the environment and social circumstance (Lin, 2011). It has four main elements: high-quality aesthetics, outstanding functions, special texture, and unique style (Chen & Chu, 2012).
- *Memory* means the old impressions in people's mind which can be used as a trigger (Lin, 2011). In Chen and Chu's theory (2012), memory has been described more specifically: "providing comfortable atmosphere, evoking memories of wonderful times, interesting metaphor, and providing romantic feeling" (p. 3).

- *Operation* measures the specific instruction from the appearance to the functions of how to use the product (Lin, 2011).
- *Process* presents the internally invisible operation that requires to be declared by external presentation (Lin, 2011).
- *Ritual of use* signifies the simplicity and convenience of daily activities (Lin, 2011).

There are another two essential factors that were not mentioned in Professor M. McCoy's theory but were discussed in Chen and Chu's study (2012) (which included 159 interviewees). *Social-esteem* suggests people want to express themselves through their taste in using products. *Engagement* refers to the hidden value of promoting health and welfare and collecting worth. Two elements that are not specified in semantic design that also play an overall role are attractive colors and interesting background story.

By adding semantics features on the product, the information and the usage goal of the product can be clearer to the users. The message transmission of the product is built on top of its shape, color, texture, and materials, which are also called the *signs* of the product. However, the theory behind those *signs* is people's emotion, impressions or knowledge which produced by various senses or imagination (Lin et al., 2011). This theory has similarities to the internal trigger previously discussed.

According to the different situation of the user groups, shared language, reward mechanism, and semantic triggers can be applied to the product to help people to understand each other's needs and have a better interactive communication.

2.5.5 Color scheme

For people who are sighted, receiving visual information is extremely important in their lives. Research shows that around 4/5 of the perception, learning, cognition, and activities are collected from vision. Among all the visual information received, color is one of the key elements. Also, color is also one of the key elements in design (Thomas, 2008).

Based on the RYB color wheel theory from Isaac Newton, this theory can be a good model for complementary colors as a well-established tool for designers. According to the RYB color wheel, there are 6 color design strategies. 1) a monotone achromatic scheme: this scheme only includes black, white, and different degrees of gray, which can be used for people who can't recognize color or people who prefer an industrial design style or similar style. 2) Monotone chromatic scheme: this scheme is using a single hue but with different lightness and saturation, similar to the first color strategy. 3) Analogous hues scheme: choose one hue and two or three hues close to the main hue.
4) Complementary color scheme: this scheme is using complementary color on the color wheel, which can provide the good color contrast for people with visual impairments. 5) Split complementary color scheme: choose the adjacent colors to the complementary color. 6) Triad color scheme: this scheme is to choose three colors on the color wheel which are equally spaced (Wegman & Said, 2011).

For the people who are sighted and people with visual impairments who can recognize the correct color, the color scheme above can be very useful in the later design process.

For people who are color blind, which includes protanopia, deuteranopia, tritanopia, and greyscale/achromato, there are 6 suggestions for using colors on the product:

- Avoid using confusing color combinations (see Figure 2.9). For example, green and red, light green and yellow, green and blue, green and brown, green and grey, green and black, blue and purple ("Designing with, " n.d.; Web Design", n.d.).

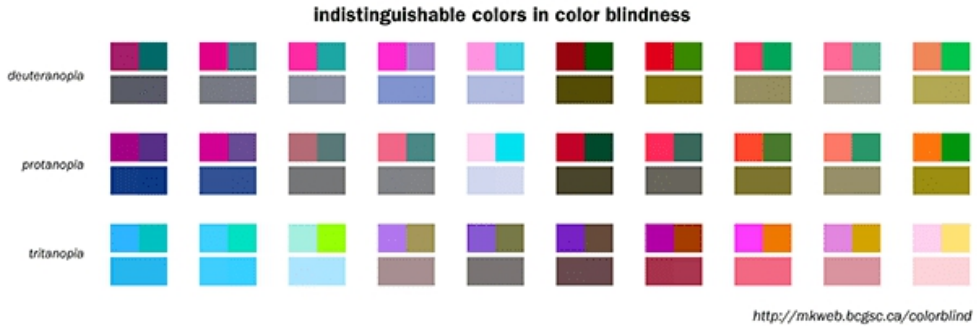


Figure 2.9 Color combinations that need to be avoided ("Web Design", n.d.)

- Monochrome can be used to avoid the confusion caused by multiple colors ("Web Design", n.d.).
- Use high contrast ("Web Design", n.d.). The website for checking the color contrast created by Snook.ca can be used to check the color contrast ("Color contrast", n.d.).
- Use thicker lines to make things show up ("Web Design", n.d.).
- Symbols and colors need to be used together ("Designing with", n.d.; "Web Design", n.d.).

2.6 Literature Review Conclusion

This literature review is a synthesis of information related to developing better living arrangements between people who are sighted and those who are visually impaired. Key insights gained in this research that will form a basis for the design guideline in the following chapter include:

1. People with visual impairments such as low vision and blindness – different visual impairments can cause different results, which means that people who are visually impaired can have different levels of remaining vision. People with visual impairments go through different stages of vision loss and typically go through a series of physical and psychological difficulties. The support from their family members and friends can help them a lot in their lives.

2. Sighted helpmates/caregivers of people with visual impairment– similar to people who are visually impaired, people with sight also go through a series of physical and psychological difficulties while taking care of the person who is visually impaired. Besides, over-protectiveness happens a lot in those families which can make the people with visual impairment less independent.

3. Living arrangements for people with visual impairment – during the vision losing or adapting stage, living arrangements can be important to develop new habits for people with visual impairments to form the traffic flow line to make their lives easier. Based on one study, there are four types of

problems that happen a lot in people with visual impairments' lives: finding, operation, identifying and labeling. Living arrangements of different combinations of different age and gender groups have unique requirements.

4. Theories and strategies of managing living environments – the life theories and strategies that have been created to make people with visual impairments to live better can be inspiring for designers to generate ideas.

5. Elements of products that promote the understanding and enhance collaboration between people with and without visual impairments – empathy and emotional curve strategies can help designers to understand the users. The strategies of shared language, semantic triggers and reward mechanism can help designers to motivate users to carry out the target activity. The last, color scheme, can help designers to pick colors for people with sight and people with visual impairment but still are able to distinguish colors.

Chapter 3 Guideline to promote understanding between people with visual impairment and people with sight

This chapter will provide a set of guidelines to help industrial designers solve problems which arise from the interaction between people who are visually impaired and sighted and to design assistive products with a communicative purpose. The previous research in Chapter 2 on the living background and product-developed habits of visually impaired and sighted persons, as well as experience with their life strategies can give the designer a better understanding of the user groups. To use this guideline to achieve their design goals, designers need to have a basic understanding of their user groups' current living situation and needs by following the instruction below. This guideline has identified six different scenarios where people with visual disabilities and people who are sighted live together.

The goal of this set of guidelines is to better summarize the design elements that designers need to consider to provide better understanding between groups and add positive experiences for their design products:

1. Analyze design requirements from multiple backgrounds and add input from multiple design disciplines to provide designers with multi-faceted thinking.

2. Design assistive products for users that are easier to use and conducive to communication and interaction to achieve cooperative behavior in the form of mainstream interaction or develop it into a habit.

The following guidelines can be considered as the design context and factors that designers must consider, and their designs will follow the order of instructions shown below: 1) Discover, 2) Define (the problem), 3) Strategies, 4) Prototype and 5) Test (see Figure 3.1). By following this guideline, the designer can save time and effort to evaluate the design and formulate the relevant solutions according to the information they get.

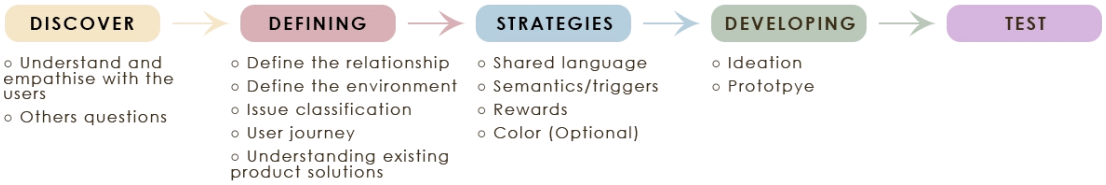


Figure 3.1 Guideline process

This guideline is for industrial designers who are providing customized or mass-produced solutions. The main focus of this guideline is helping designers to develop a customized solution for one household. 3D printing and other model making ways can be used to make customized products, while colors can be painted later on. What's more, when the problem is universal and happens to several families and is used in similar scenarios, the solution can be mass-produced as long as the functions, features, and colors of the product meet users' needs and have good contrast with the indoor environment.

This guideline leads designers to come up with product-based system solutions, for example, using products to create a habit-developing system.

3.1 Discover: Understand and empathize with users

From the very first, understanding and empathizing with the users are the most important steps of product design. Designers need to have a full understanding of the conditions of participant groups, living environment, problems, needs and existing products in the market before starting divergent thinking in design. In this part, the participants are people who are sighted and people who are visually impaired living together. Figure 3.2 illustrates the overall design process highlighting this phase.

Figure 3.2 Product design process - Discover stage

3.1.1 People with visual impairments

When their previous way of life is changed by the onset of a visual impairment, the affected people need to find a new way of life by using the remaining sight, other senses, and/or other abilities. Exploring the limitations of people who are visually impaired can help designers understand the range of divergent thinking they can do when designing products.

Designers must consider many different types of users with different abilities. There are some influencing factors associated with the final product which need to be addressed before design work begins.

In this guideline, people whose vision is lower than 20/40 with conventional prescription lenses or have a restricted field of vision less than 20 degrees wide are

considered visually impaired (“What Do”, 2016; “What is”, n.d.). Since visual impairment does not mean complete blindness, the designer should understand what kind of physical ability the users with visual impairment have, which will provide effective functional reference for the following design steps.

Figure 3.3 shows the understanding of the users and environment.

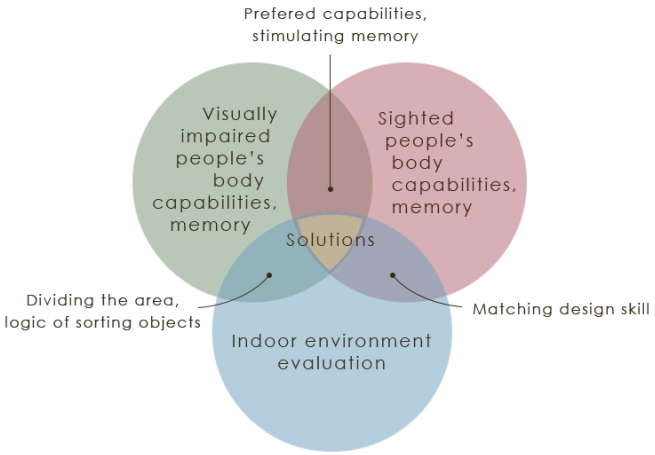


Figure 3.3 Understand the users and environment

3.1.1.1 How old are they?

To some extent, the information on age can help designers to choose the reward mechanism for their design in the next Defining step. For children, curiosity and exploration are the biggest help that can establish a new habit. Designers can practice divergent thinking in areas where children are trained and encouraged. For example, reward of hunt can be a good element to apply on the product for encourage children to produce the target behavior. For teenagers, adults and the elderly, strong learning ability and the desire of independence would make them more eager to develop new habits to adapt to the new way of life.

3.1.1.2 What stage is the person with visual impairment at now of the vision loss?

By understanding the stage of vision loss, designers can know the urgency of the motivation of activate the behavior.

- **Beginning Stage:** When a person with visual impairment has recently lost vision (i.e. two weeks), the person who's losing vision and the family members are still processing the new situation and going through the psychological and physical difficulties, so the design of the product needs to have stronger, clearer, and more explicit semantics to trigger the behaviors to fit the "new shocking contradiction".
- **Adaptive Stage:** When person with visual impairment is in a slow loss of vision, the designers need to focus more on design concepts about developing habits.
- **Adjusted Stage:** When person with visual impairment person is already used to the inconvenience from the vision loss.

3.1.1.3 What have the visual impairments changed in vision? (Choose what situation are they in)

Due to the influence of different visual impairments, most people who are visually impaired still maintain certain visual judgments such as color, shape, and others. Some visual impairments can also have a significant impact on the perception of light. This step can help designers to know if they can use visual elements on their design and which type of elements is suitable. See expanded definitions of these areas in Chapter 2.1.1.

- **Partial loss of visual field**: People can only see objects in some certain scope (central or peripheral/tunnel vision).
- **Decrease or increase of lighting requirements**: This type of situation usually happens when people have night blindness, high sensitivity to glare, difficulty in light-dark adaptation, high brightness requirements and so on (Duffy, 2002).
- **Hazy vision**: Overall blurring and haziness of vision, which can cause the low sensitivity of contrast, depth perception, or unable to focus close up and others (Duffy, 2002).
- **Decreased color perception**: A person has difficulty in distinguishing colors.
- **Distorted vision**: The shape of objects will be hard to distinguish.
- **Fully Blind**: Visual impairments that are not correctable with spectacles, contact lenses, or surgical intervention and that interferes with normal everyday functioning. See Chapter 1.4, definition of terms.
- **Other**: Used to describe situations have not been mentioned above.

What other senses can be used to convey information about the environment and things in it?

When visual elements are not the best solution to apply on the product, there are other senses that can be applied. Some sensory capabilities are useful and may be emphasized (Strickfaden & Devlieger, 2011), which can be very important for people with visual impairment to acquire a new richness and power. If the visual factor cannot be a design element due to the limitation of vision loss, the designer needs to consider the orientation of other senses and abilities.

What senses do they prefer or usually use to locate or analyze items?

- Visual: Residual vision (color, shape recognition);
- Auditory: All kinds of sounds;
- Touch: Different textures, shapes, weight, temperatures or the sounds it makes;
- Olfactory: A variety of different smells.

If the user who is visually impaired and has compensatory sensory growth because of the vision loss, which is discussed in the literature review 2.1.2, designers should consider applying the compensatory senses features towards their solutions. If the user prefers color for receiving information, designers need to choose color strategies suitable for the current scenario according to the different visual conditions of people with visual impairments. If the user prefers auditory, designers can try to apply different pitch and timbre on the product. If the user has the special olfactory preferences, designers can apply scents on the product.

By understanding the preferences for the person with visual impairments, designers can apply a suitable sense of the triggers for the target product.

3.1.2 People without visual impairment

Designers need to use the semantic meaning of the product to encourage people to form behaviors to promote collaboration between people who are sighted and people who visually impaired. People who typically live with a person who is visually impaired fall into six categories: adult partners, ageing partners or elder relatives, young parents,

children, friends, and roommates (acquaintances). Different triggers and rewards should be applied based on the different types of users.

The external triggers can refer to the semantic expression forms mentioned in Chapter 2, and the person who is sighted is more inclined to express the form through inquiry and observation. The reward mechanism can be divided into three types: reward of hunt, reward of self and reward of tribe, which has been discussed in section 2.5.3.

3.1.2.1 How old are they?

Understanding the age of the person who is sighted can help designers to choose a more appropriate reward to apply to the product.

For children with sight, some of them are likely to have rebellious psychology because their parents are frequently seeking help from them. Therefore, when designers come up with solutions for these children, they need to do more product case studies on the reward mechanism of habit formation.

For teenagers and adults, balancing time is one of the most difficult tasks in one's own life when caring for others. On top of that, money is also a constant worry for family members. Industrial designers need to conduct in-depth analysis through interview with sighted participants, field visits, by investigating secondary data, or other methods.

For the ageing people who are sighted, the limitation of physical strength will be a great inconvenience, but the actual situation requires designers to conduct in-depth analysis through interview with sighted participants, field visits, by investigating secondary data, or other methods.

3.1.2.2 What senses do they prefer?

To better understand the preferences of the people who are sighted living with a person who is visually impaired, designers can ask the participant what senses do they prefer or usually use to locate or analyze objects? In this way designers can apply the best solutions for sighted people on the target product.

- Visual: Color or shape recognition;
- Auditory: All kinds of sounds;
- Touch: Different textures, shapes, weight, temperatures or the sounds it makes;
- Olfactory: A variety of different smells.

Base on the user's preference of the way receiving information, designers need to choose color strategies suitable for the current scenario according to the age and characteristics of the user.

3.1.3 Additional questions

These additional questions for both people with visual impairment and people who are sighted can help designers choose the appropriate Semantic Triggers for their solution during the strategy phase.

- Do the participants have strong requirement of matching styles between the product and the environment?
- What type of feelings do the participants want the product to convey?

- Is there any special memory of interaction between the people who live together? Special memory from the products they have used?
- Do the participants have any other disabilities?
- Do they have any hobbies or collections?

The design tools shown in Figure 3.4 allow the designer to gather the information of the users themselves in the table below. “Others” can be the additional information from asking the questions listed in 3.1.3.

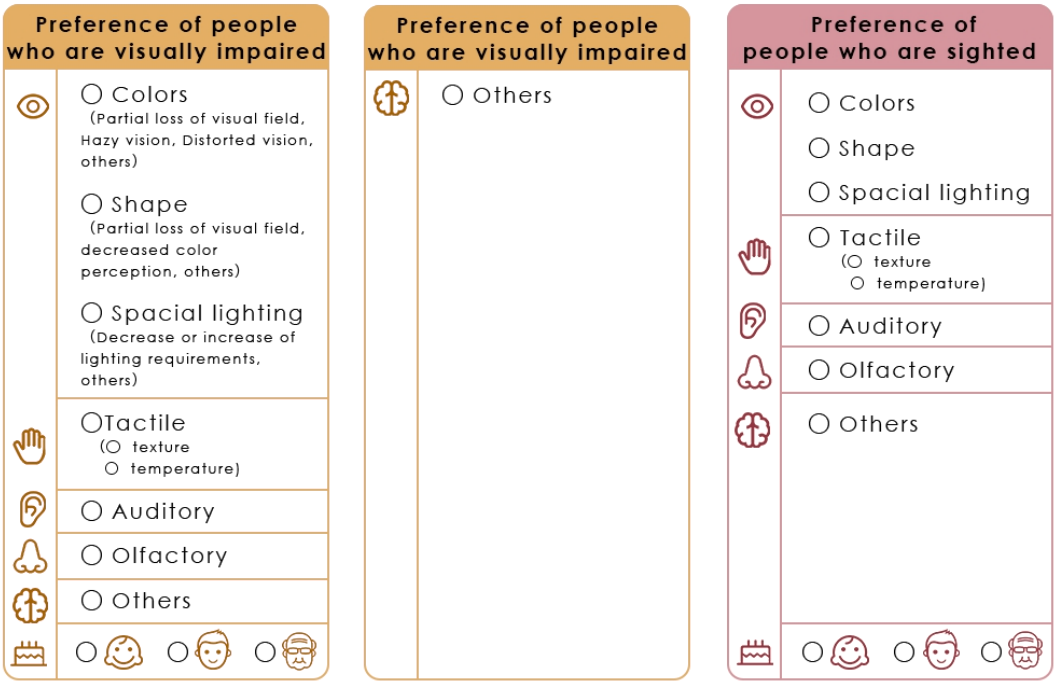


Figure 3.4 Preferences of people who are visually impaired and of people who are sighted

3.2 Define the problem

Figure 3.5 illustrates the Defining step: Understand users’ relationship, living environment, and problem.

Figure 3.5 Product design process - Define stage

3.2.1 Define the Scenario

3.2.1.1 Who are the people living together? What's the relationship between them?

1. **People who are visually impaired who have family and friends come to visit**: In the relationship with families and friends, people trust each other and are more willing to care about each other. They will have higher pursuit for searching out, the same goals which can make both parties feel more comfortable in the living environment.
2. **One person with visual impairments in an adult couple**: This familial relationship has the same desires as above.
3. **Parents who are sighted and children with visual impairments**: This familial relationship has the same desires as the first group.
4. **Children who are sighted and parent with visual impairments**: This familial relationship has the same desires as the first group. However, this group requires parents to be more independent in order to make their children feel less of being used as a tool.
5. **Person who is ageing with visual impairment living with adult partner, or with their adult children:** This familial relationship has the same desire as the first group.

6. **Person with visual impairment living with a non-family member (roommate)**: “knowledge of a person acquired by a relationship less intimate than friendship” (American Heritage Dictionary, 2011b). Because the relationship bond between people who are visually impaired and acquaintances are not as strong as with friends and families, the triggers and rewards designers use for the product must be popular and with strong semantics for general people.

3.2.1.2 Type of living environment (communal living spaces between people who are sighted and people who are visually impaired)

Evaluating the overall residential living environment will help designers analyze how to shape the best way to solve problems, giving suggestions for rearrangement to prepare for the next step of product design and help people better develop new habits using assistive products designed for the specific environment.

While evaluating the environment of the house, designers should record the design style and main colors of the house. If there is a demand for the color design of the product in the later stage, the approximate color of the main color of the house can be used to be close to the environment or contrasting color can be used to make the product catch people's attention in the environment.

The size of the living space may limit the ability of people who live in that space to hearing audible cues. If the space is too big, designers may need to choose senses to utilize in their design other than hearing. For example, within a multi-story house the

shared living space is large, so the sound effect cannot reach the best transmission effect over a long distance.

Single floor dwelling: To live together in a relatively large space, the area should be divided, for example, furniture can be a good tool to separate the space, so that people with visual impairment can grasp the spatial relationship faster and get familiar with the moving line.

Apartment: Common living space usually is small.

The design tool shown in Figure 3.6 allow the designer to gather the information about the living information in the table below.

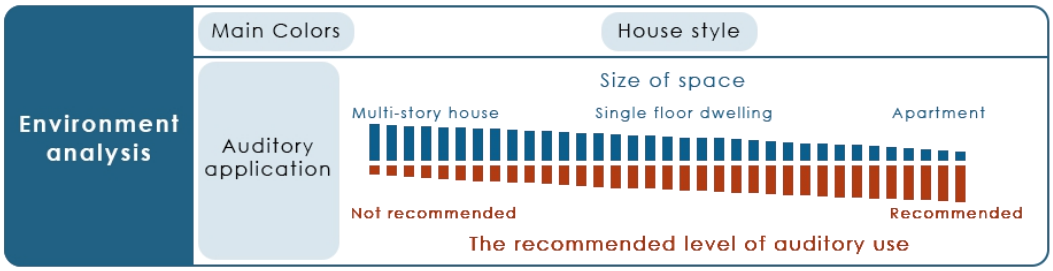


Figure 3.6 Summary of living environment

3.2.2 Interactive issue classification

To identify the scope of the design, the interactive issue classification should fall into one of these four categories: finding, operating, identifying, and labeling.

1. **Finding issue**: People frequently do not remember to put objects back, miss the original spots or the order of the objects. For example, find something on a crowded shelf and others.

2. **Operating issue**: This refers to the order of operation, such as where is the operation dash or button and how is it operated correctly? People who are visually impaired frequently need to ask for help when there isn't an assistant tool (e.g., using appliance dials, buttons and remotes and other cases), which could interrupt the activities of the people they live with.
3. **Identifying issue**: When objects are difficult to identify for a person with visual impairment, they frequently need assistance or help from someone they live with. For example, they may need help to identify medicine.
4. **Labeling issue**: People who are visually impaired sometimes use unique strategies to identify objects (such as Braille labeling or color coding). This type of strategy sometimes bothers other people in the environment by making it difficult to read or identify the original product labels.

Classifying the issue type can help designers use less time to figure out the direction of the product design. But to truly understand the issue between people who are sighted and people who are visually impaired, the designers should do an analysis of the particular experience.

Based on the background knowledge and preferences from the Discover step, designers can make a chart comparing the abilities and needs of both parties, then come up with the match point (which means using the minimum design and function to maximize the effect). If there isn't a perfect match point, designers can look to combine different functions to fit the needs for both parties.

3.2.3 User journey map

Designers can use observation, interviews, second-hand research, or other ways to record details of users' needs, behaviors, feelings, and interactions. Then they should collect the information and create the emotional curve to analyze the positive and negative emotions while users carry out the activity. This step can help designers to discover the pain points of the problem in the activity.

This user journey map will include two parts: 1) process of the activity, and 2) the emotional curve. There are four parts in the process of the activity: users' column, actions, conversations, and interaction lines. The users' column will be on the left, which will include the users' profile pictures, names and the roles in the relationship. Actions will be put in the center of the journey circle (blue circle in the example). Important conversations, which lead the actions, need to be recorded and put beside the actions. Interaction lines are across the actions, and only show up when the users are having interactions between each other, for example, the blue and red lines across the blue circles (see Figure 3.7).

The emotional curve is mainly about recording the emotional changes of the users along the activity from the beginning to the end. The emotional curve in the user journey should be recorded by observing the users, interviewing the users, or making guesses based on the designer's knowledge and understanding. When the users feel normal, upset, angry, happy, or others, designers should mark those emotions under the corresponding actions in the process of activity. The negative emotions represent the potential pain points of the interaction and the activity, which should be a focus point for the designer.

This is an example that shows how the user journey map can be created in the design implementation in section 4.1.

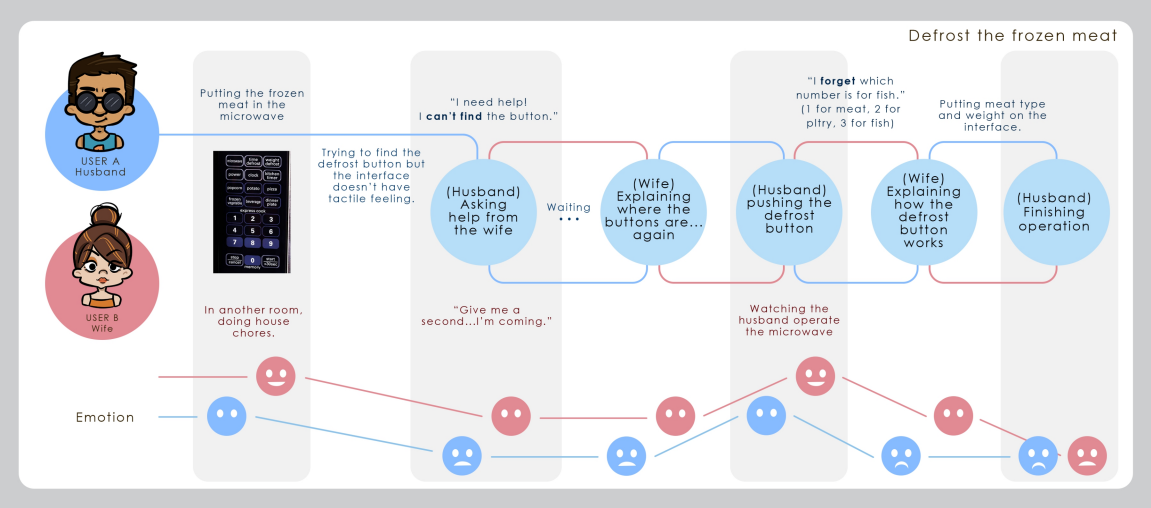


Figure 3.7 User journey of the second implementation

3.2.4 Understanding existing product solutions

According to the visual ability, preferences, and other information of the user who is visually impaired, and the preferences and other information of the user who is sighted, by doing online research or using other methods to know what products are related to the current problem are available on the market, how the products perform, the technologies the products used, and the function or feelings the products conveyed. Then designers can conduct a case analysis of sensory design products based on the senses the users prefer, existing relevant strategies (optional – strategies discussed in section 2.3.1 and 2.4), and products related to users' characteristics or personalities. By analyzing the data from the product research, designers may be able to come up with what function, trigger, and technology they can use and apply to their products.

The design tool shown in Figure 3.8 allows the designer to gather the information about the solutions which are related to the current problem in the table below.

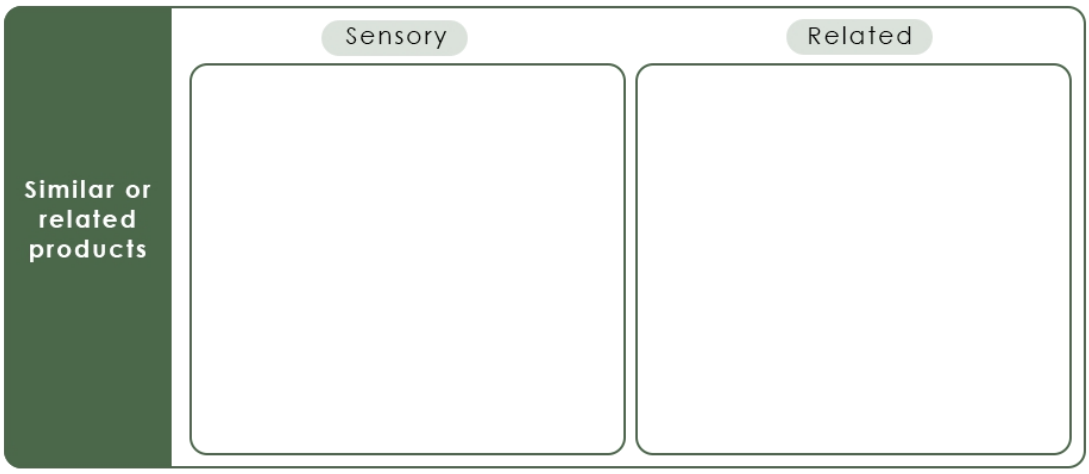


Figure 3.8 Similar or related products

3.3 Strategies

In the third stage (see Figure 3.9) the designer will select strategies to use in their design implementation.

Figure 3.9 Product design process - Strategies stage

After collecting all the product research and strategies, designers can categorize the product type needed, and the semantic triggers that might be applied. After categorizing the products, designers can analyze why the figures are important and showed up on the product(s). Based on the analysis, designers can start picking the strategies below.

3.3.1 Semantic triggers

To encourage people to perform the intended behavior, the appearance of the design should provide a feature to trigger the action.

Based on Professor McCoy's theory and Chen and Chu's study, which was discussed in the literature review, section 2.5.4, this guideline has divided the abstract semantic concepts into 14 specific effective strategies/elements which can be applied on the product:

1. High-quality aesthetics
2. Outstanding functions
3. Special texture
4. Unique style
5. Provide comfortable atmosphere
6. Evoke memories of wonderful times
7. Interesting metaphor
8. Provide romantic feeling
9. Implication of operation from the product appearance suggests how to use the product
10. Implication of process refers to internally invisible operation being declared by external presentation
11. Ritual of use signifies expresses simplicity and convenience
12. Building social-esteem through their taste in using products
13. Hidden value of promoting health and welfare
14. Collecting worth

Once designers evaluate the information collected from their user in the previous two steps, Discover and Defining, they can review the semantic trigger cards provided in this guideline in order to be able to pick one or more of the triggers suitable for their users based on the previous information they gathered from the users, environment and the product research. Figure 3.10 shows images of the guideline tools for semantic triggers. The card color and back of the card show each of the five trigger categories. The title of the card is the trigger type, below the title is the explanation of how the trigger should work, and the bottom part of the card is the sample of how the trigger can be applied. If designers have trouble understanding the trigger names, then they can read the samples on the cards.

(Butterfly stool adapted from Butterfly stool, n.d.)

ENVIRONMENTAL CONTEXT

OUTSTANDING FUNCTION

OUTSTANDING FUNCTION

Selecting and distributing the function will be the first priority of the design.

SAMPLE

The Braille Computer

ANALYSIS

The product's functional layout is maximized for user convenience, and all functions are appropriately assigned.

(The Braille Computer adapted from The Braille, n.d.)

ENVIRONMENTAL CONTEXT

SPECIAL TEXTURE

SPECIAL TEXTURE

By adding different textures to convey information.

SAMPLE

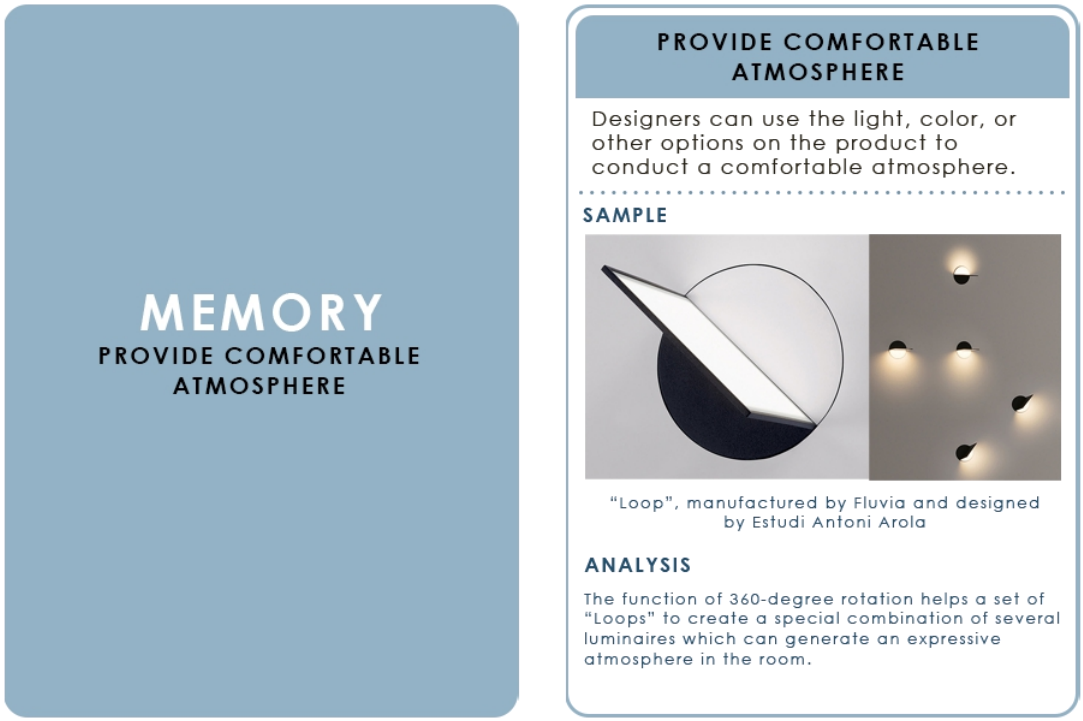
MYNT3D Professional Printing 3D Pen

ANALYSIS

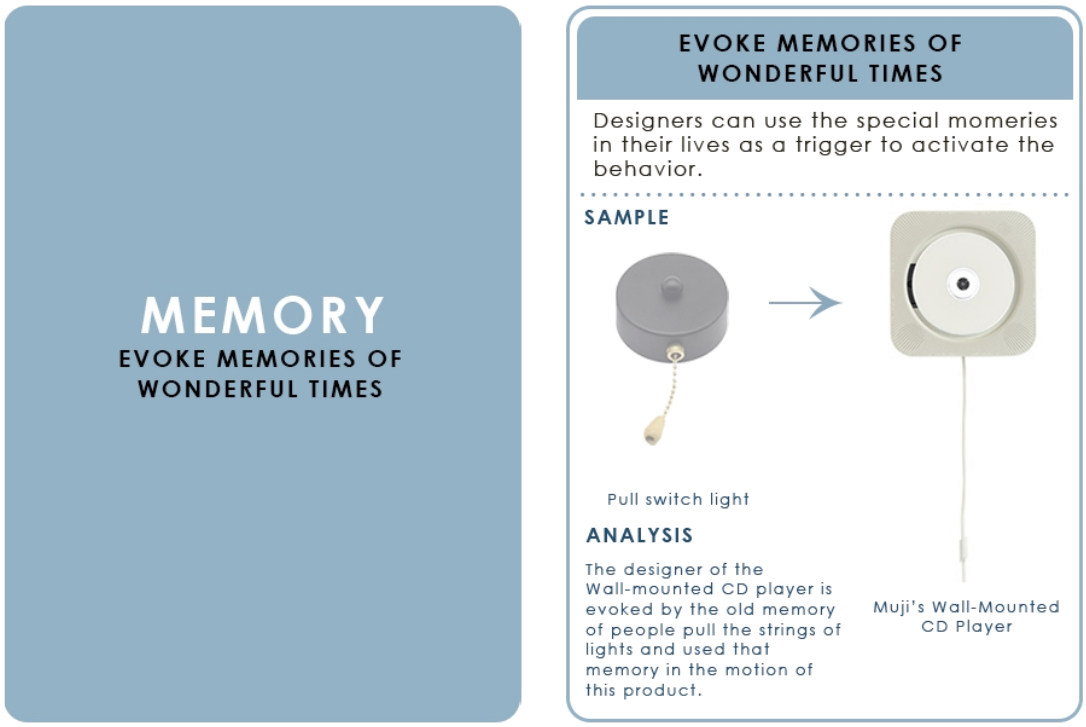
This product can create a different texture on different surfaces.

(MYNT3D Professional Printing 3D Pen adapted from MYNT3D Professional, n.d.)

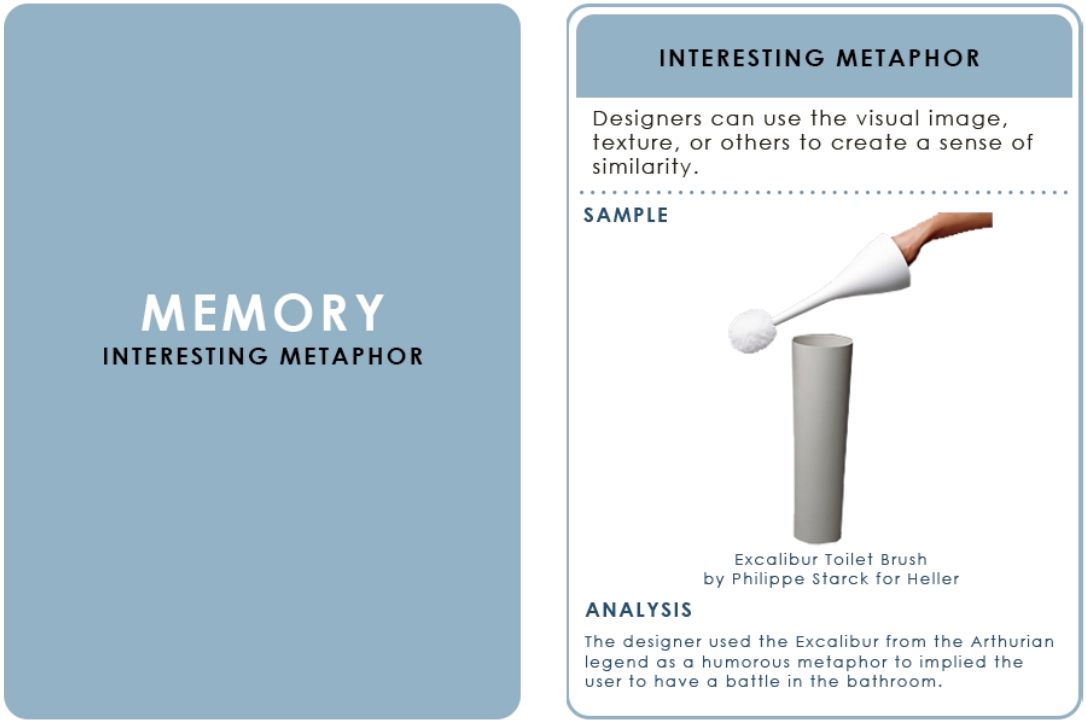
(Sabrina Fossi : FreakishCLOCK Wall Clock adapted from Deau, 2013)



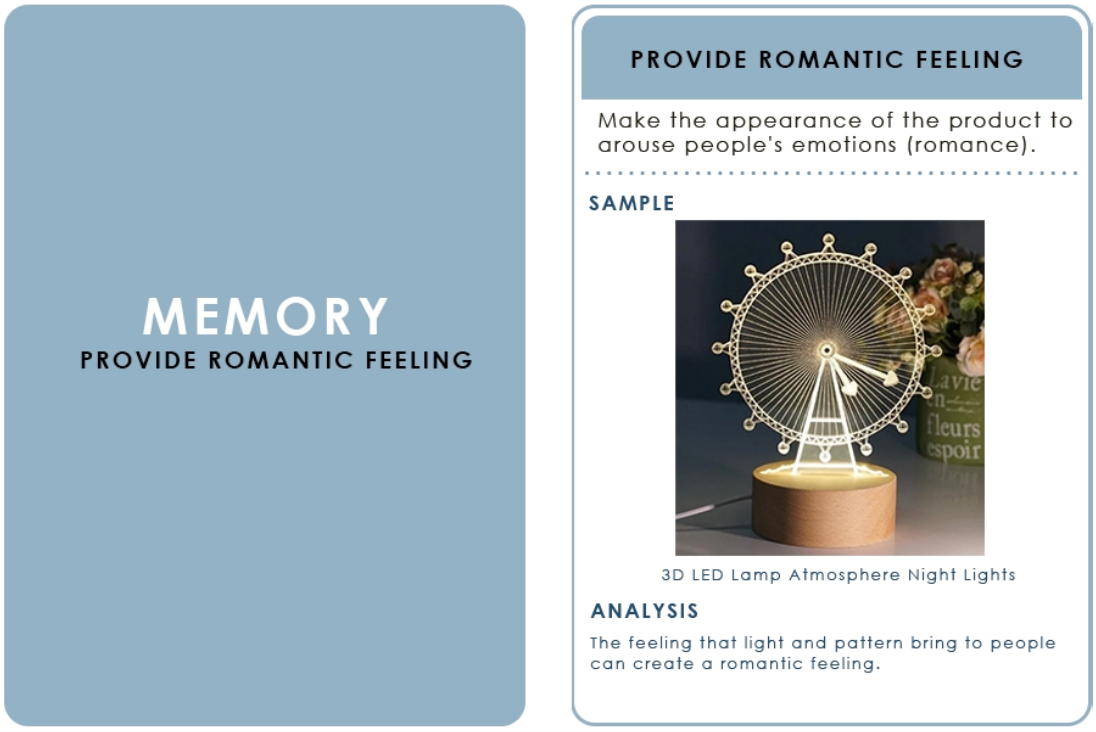
(Loop adapted from “In a”, n.d.)



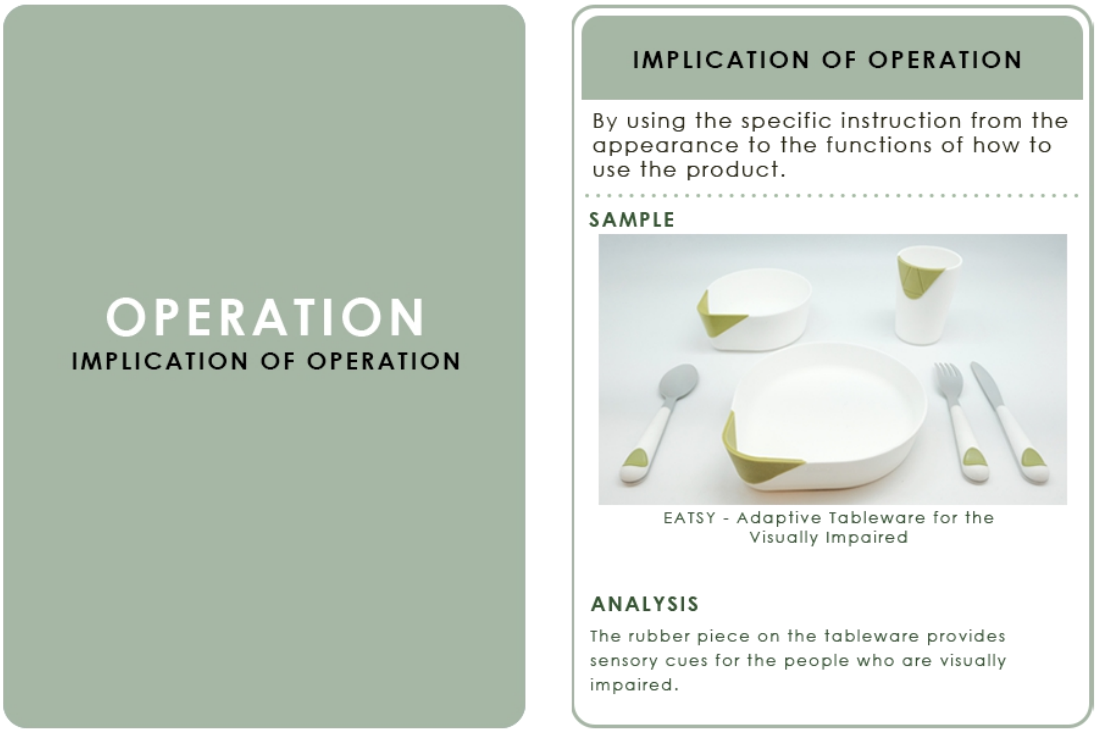
(Muji's Wall-Mounted CD Player adapted from Wall mounted, n.d.)



(Excalibur Toilet Brush adapted from Excalibur (Heller), 1996)



(3D LED Moon Lamp Atmosphere Night Lights adapted from 3D LED, n.d.)



(EATSY - Adaptive Tableware for the Visually Impaired adapted from Lim, 2017)

PROCESS

IMPLICATION OF PROCESS

IMPLICATION OF PROCESS

The internally invisible operation that requires to be declared by the external presentation.

SAMPLE

Rockstick 2 Mouse

ANALYSIS

The shape and button of the mouse clearly implied the internal operation.

(Rockstick 2 Mouse adapted from Rockstick 2, n.d.)

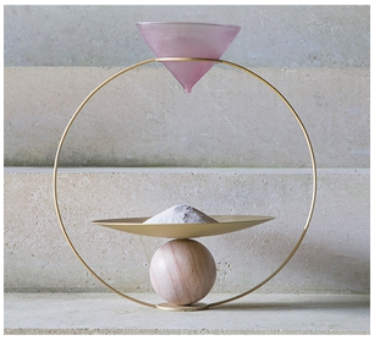
OTHERS

RITUAL OF USE

RITUAL OF USE

The simplicity and convenience of daily activities.

SAMPLE



MADE IN EDIT_ORA
(from Sara Ricciardi & Simone Piva)

ANALYSIS

The design of the product clearly showed the simplicity of the usage for daily events.

(MADE IN EDIT_ORA adapted from Beall, 2021)

OTHERS

BUILDING SOCIAL-ESTEEM

BUILDING SOCIAL-ESTEEM

The design of the product can express users' taste through using products.

SAMPLE

UNIFORM

ANALYSIS

UNIFORM is a relatively lively product. By using reading the user's emotion and matching music, UNIFORM can represent the user's taste of music.

(UNIFORM adapted from Brewer, 2016)

OTHERS

HIDDEN VALUE OF PROMOTING HEALTH & WELFARE

HIDDEN VALUE OF PROMOTING HEALTH & WELFARE

The design of the product has the hidden value of promoting health welfare.

SAMPLE

Voice Sticker for Blind

ANALYSIS

This product can activate a recording sticker and play the recorded voice message to improve the lives of people who are visually impaired.

(Voice Sticker for Blind adapted from Voice Sticker, n.d.)

(Splinter adapted from Williamson, 2013)

Figure 3.10 Semantic triggers explanations and examples

3.3.2 Shared language

To design a product that can bring better understanding between people who are visually impaired and people who are sighted, designers need to be flexible in using a combination of senses, for example, combining visual sense with tactile sense. Visual images used on the product can provoke the memory of people who are sighted to activate a behavior, and the tactile impression from the product can give people who are visually impaired a clue of what they need to do at the same time.

When participants chose two different types of senses, for example, when a person who is visually impaired chose special texture and the person who is sighted choses visual image, then the designer is recommended to consider using a shared

language strategy to apply on the product. For example, only people who know Chinese characters or English words can understand the text version "car", but all people can understand the picture version of “car” (Figure 3.10).

Figure 3.10 Chinese characters, English word, and graphic of “car”

3.3.3 Rewards

Reward strategies of developing habits: According to the previous discussion, rewards strategies can help people to repeat the behavior. If the problem type is a finding issue, then designers are suggested to use this strategy on the product. Based on the participants’ relationship, designers can choose the best reward type to apply (see Chapter 2.5.3 Habit Development).

1. Reward of tribe: the pleasant emotions from the efficient communication, collaboration, and network with other people. One example of reward of tribe is the Friendship Lamp which provides people who are in long-distance relationships the ability to know that another person is thinking about him or her and strengthens the bonds between them, as shown in Figure 3.11.

Figure 3.11 Friendship Lamp (“Friendship Lamp”, n.d.)

2. Reward of hunt: exploring desirable resources by themselves. This reward can be the motivation for children who still have a great passion for exploring the world. One good example of application of reward of hunt is a kaleidoscope, which can constantly change the patterns observed by turning it and getting people interested in hunting a new pattern.
3. Reward of self: the gratification from solving the problem, completing a task, or improving abilities and others. One case of the application of reward of self is SAHN Kickstarter, shown in Figure 3.12. This product uses giving a person their favorite thing to encourage themselves to develop new habits. At the beginning, the user needs to write down on a note what they want to reward themselves with and put it in the container. When the user finishes the target behavior, they can pull one bead from one side to another side and get one reward according to the note.

Figure 3.12 SAHN Kickstarter

3.3.3.1 Selection of colors (Optional)

For the user group who prefers color and does not have color blindness, according to the color and style of the environment, there are six color schemes can be applied to the design: the monotone achromatic scheme, monotone chromatic scheme, analogous hues scheme, complementary color scheme, split complementary color scheme, and triad color scheme.

For the user group who prefers color but has color blindness, designers need to use Figure 3.13 to check the color combinations that need to be avoided. Use the website https://snook.ca/technical/colour_contrast/colour.html#fg=,bg= to check the color contrast.

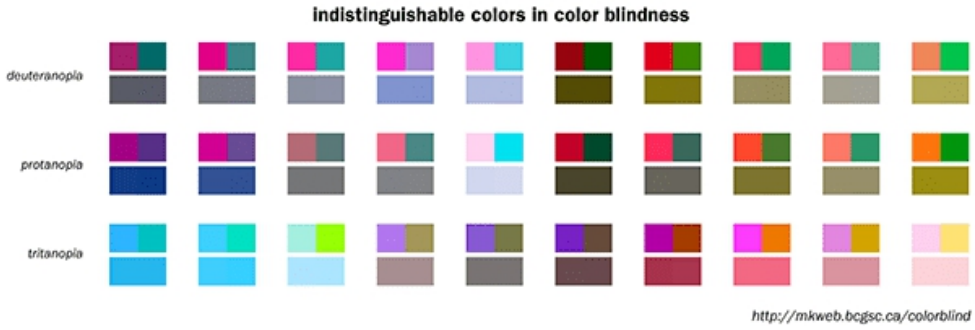


Figure 3.13 Color combinations that need to be avoided

3.3.3.2 Selection of material (Optional)

For people who prefer senses other than vision as the semantic triggers, selection of materials can be important. Different materials can bring the feelings through temperature, weight, texture, shape, and the sounds it makes. For example, the metal piece on the end of the white cane (the tool to assist people with visual impairment to walk unassisted) can make unique sounds when it touches different materials.

3.4 Developing

Figure 3.14 Product design process - Developing stage

Figure 3.14 represents the Developing step which represents typical methods in the design thinking process, including ideatation and prototyping. In the ideate stage, industrial designers can draw plenty of innovative ideas according to the guidance of the strategies, the information they have gathered from the users and others; then pick one strategy or combine two or more to start their creative design. In the prototype stage, the designers should build the product as real as possible (Gibbons, 2016). Designers could use any type of ideation (for example, sketching, storyboard, mood board, mind mapping, and so on), and prototype method (e.g. scale model, low or high fidelity mockup and others) in this process.

3.5 Testing

Figure 3.15 Product design process - Test stage

To test the solutions from the previous step, there are two questions that need to be asked (Figure 3.15). Can the solution improve the cohabitation between people who are visually impaired and people who are sighted, and at what level it has contributed? To answer the questions, the methods need to be used in this stage are interview the users to get feedback or observe the users' interaction with the product.

To know the effectiveness of the applied strategy, based on the essential elements previously discussed, there are a few areas that should be measured:

What information did participants receive from the appearance of the solution?

- What actions were triggered by the solution?
- To what extent do participants want to use the solution or engage in targeted behavior during the usage time?
- How often did the problem happen before and how often does it happen now?
- How does the appearance of the solution affect the environment style?
- If different actions are triggered by the solution, then what makes participants think that way?

A test sheet has been created to help designers to organize the results from the interview or observation of the effectiveness of the solution. A full size version of the sheet is included in the Appendix.

Solution name

- Solution type (system/product/others)
- Designer:
- Interview ○ Observation ○
- Date:

Scenario

- Relationship type:
    - Indoor environment type:
    - Problem type:

Strategy selection

- *Semantic trigger application:*
- *Shared language application:*
- *Rewards mechanism application:*

Purpose of strategy (What information should target groups receive? What actions should be activated by the product?):

- Towards the person(s) with sight:
- Towards the person(s) with visual impairment:

Using effects

- What information did target groups receive?
    - Person(s) with sight:
    - Person(s) with visual impairment:
- What actions were activated by the solution?
    - Person(s) with sight:
    - Person(s) with visual impairment:

Effects

- Effect of trigger (To what extent do participants want to use the solution or engage in targeted behavior?)
    - Person(s) with sight
        - Above expectation, In line with expectation, Below expectation
    - Person(s) with visual impairment
        - Above expectation, In line with expectation, Below expectation
- Frequency of the problem (before & after)
    - Person(s) with sight
        - Lower than before, Same frequency as before, More often than before
    - Person(s) with visual impairment
        - Lower than before, Same frequency as before, More often than before
- Aesthetic (bonus)
    - Matching degree between product and environment:
        - Good, Acceptable, Not quite well

3.6 Summary of the Guideline

This chapter has provided guidelines to help industrial designers solve problems which are arising from the interaction between people who are visually impaired and sighted in designing assistive products with a communicative purpose.

In the Discover phase, the industrial designers need to understand and empathize with people who are visually impaired and who are sighted. By understanding the age and personality, the stage of the vision loss, remaining vision of people with visual impairment and people with sight, designers can have a general understanding of the users. By knowing their preferences of senses, it will give designers some directions of what the product feature and function should be like. There are also some extra questions to help designers to understand the users more.

In the Defining phase, designers should figure out the relationship between the users and the living environment. Then, they Define the issue category next. If conditional, the designers can make a user journal to review the pain point of the activity and then do second-hand product research about related or similar products.

In the Strategy phase, based on the information from above, designers should choose the suitable strategies according to user's age, personality and ability, and the living environment.

In the Developing phase, for the ideation stage, designers are going to apply the strategies to their ideas by using sketches, brainstorming, storyboard or other typical industrial design developing process, and for the prototype stage, designers can make 3D models by using 3D printing, scale model or other ways to make the model.

In the test phase, industrial designers can choose to test their product by asking the questions listed in the testing step.

Chapter 4 Designing with understanding and enhancing collaboration

This chapter will demonstrate two different implementations of this designing with understanding and enhancing collaboration guideline starting with two different user scenarios and showing how the elements for the guideline can result in different design outcomes.

Although the design approach of understanding and empathizing users succeeds better while having real users involved in the process, for the two implementations discussed here the author relied on secondary online research to illustrate how the steps in this guideline can result in thoughtful product development.

Any preferences and choices made by the users in this implementation were actually created by the author to illustrate how to use the guideline based on secondary research and literature review.

4.1 Implementation 1

The first design implementation was explored using this guideline to build a healthier relationship and encourage the interactive communication between ***parents who are visually impaired with a sighted son***.

4.1.1 Define the scenario and understand and empathize with users

Stepping into the design process, the user's physical information, living relationship, living environment, and interactive activity are defined as parents who are visually impaired with a sighted son (under 14). Activities like playing with toys together, organizing objects and preparing food are listed because those things happen frequently between the participants. Playing with toys together is chosen as the activity to focus because interactive communication working as a habit development can drive toward a good outcome. The environment is defined as the living room (shared space) in the house.

To define the issue, online searching and reviews of parent's interview video records were the main resources to understand the target users and focused on the target users' interaction and communication after playing with toys together. The users defined in this paper were compiled from those described in the literature review and other online research from these sources: John Hull wrote in his book *On Sight and Insight: A Journey Into The World of Blindness*, "the whole house, from top to bottom, was littered with unfamiliar objects, children's toys all over the floor"(p. 46); the YouTube video *Blind with a Baby*, the child didn't put her ball back so the mother couldn't know the ball was behind her chair (The Dub Crew, 2019); the article *Kids Toy Storage Sets to Organize Your Kids Bedroom* on the website "They are messy and need all their toys scattered on the floor. This cluttering requires great effort by the parents when it comes to it cleaning up" (Sandhu, 2010).

Through this review of comments from parents who are visually impaired, the issue in this kind of activity can be defined as a *finding issue*. Following the guideline, an interaction and communication journey map was created from this research to illustrate

the general process of playing with toys. It is separated into four sections: preparing, explaining, and choosing game, playing, and organizing (Figure 4.1). An emotion variation flow derived from this research is shown below the interaction process. The unhappy faces that showed up at the end of the journey point out that in the finishing work stage (organizing section), collecting, sorting toys back together and putting all the items back to the right place is a struggle for the parents who are visually impaired and the child with poor patience.

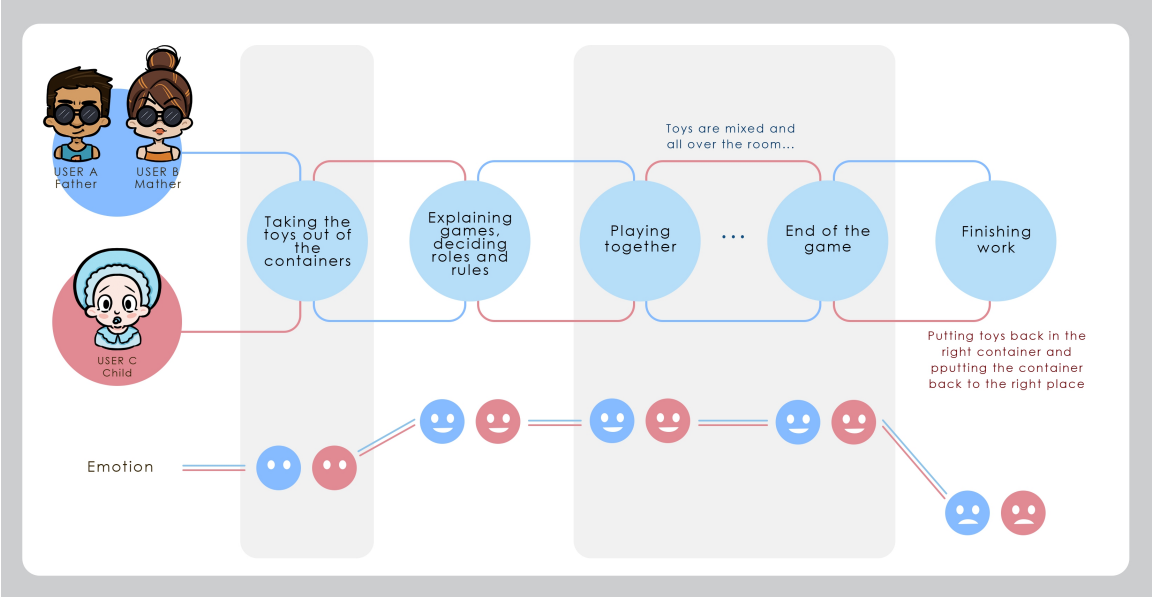


Figure 4.1 User journey map for parents who are visually impaired with a sighted son

Next, more details are needed to make the user information clearer, as seen in Figure 4.2.

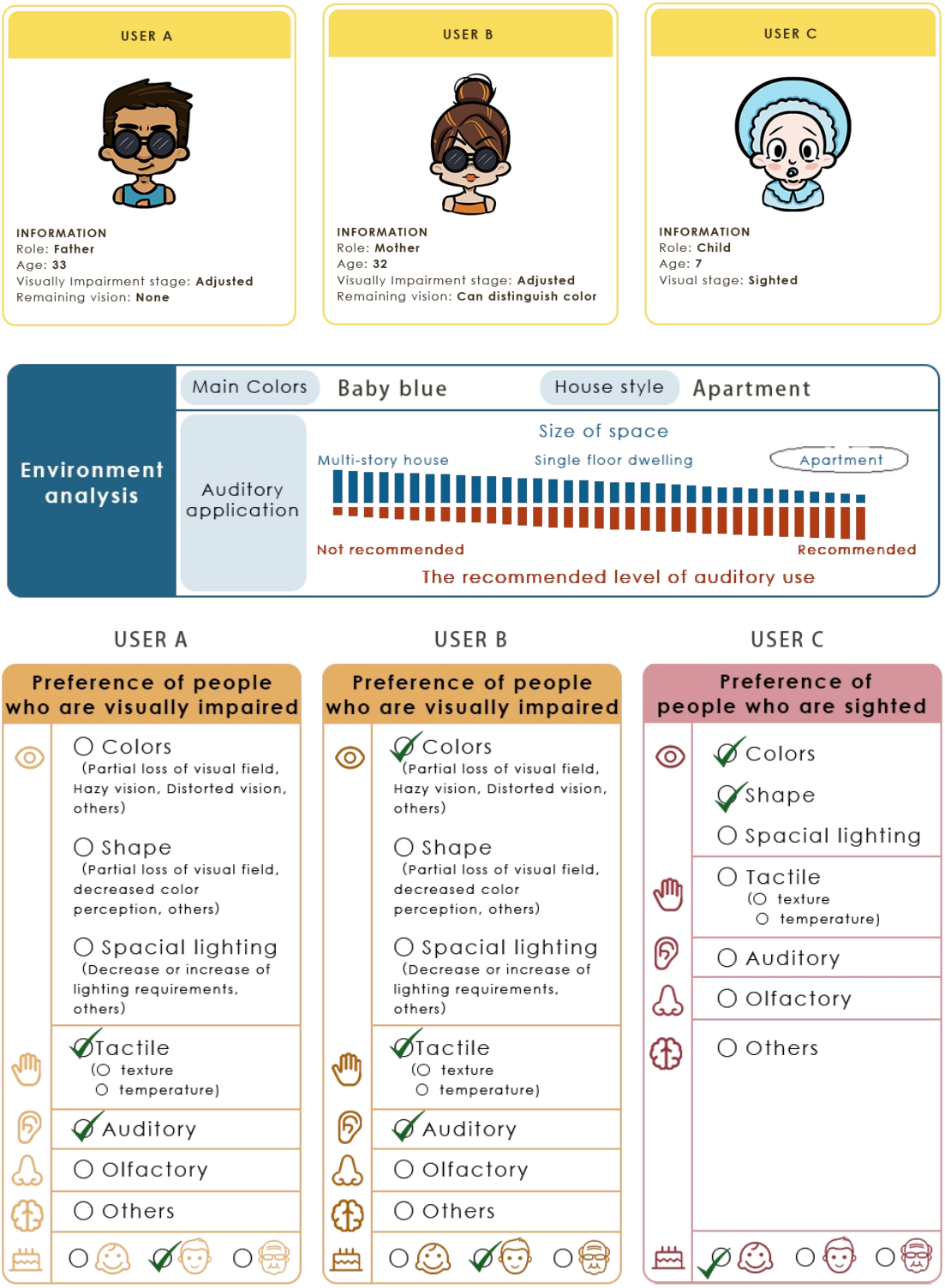


Figure 4.2 User information

4.1.2 Researching existing products

The basic information of the target users can help the designer make decisions of the product type, color, functions and so on. In this design implementation, the preferences of parents who are visually impaired here were arbitrarily chosen to show how the guideline can be implemented. According to the above knowledge, the parents who are visually impaired both prefer the touching or hearing senses.

The existing product research is divided into three categories: products for sorting objects (toys), products that have special tactile feature for people who are visually impaired, and products designed for 7-year-old boy (see Figure 4.4.)

Figure 4.4 Existing Product Research

1 Kids closets, n.d.	2 Jen, 2020	3 Sheth, 2020
4 Mcnulty-Kowal, 2021	5 IKEA Trofast, n.d.	6 Sheth, 2019
7 Dhingra, 2019	8 Yu, 2017	9 Kim, 15
10 Fong, 2021	11 Wilson, 2013	12 Sheth, 2021
13 Turner, 2014	14 Childrens Sensory, n.d.	15 Sheth, 2021

There are four essential elements towards the design of products that have been abstracted from user and existing product research: protrusion (tactile), modular (sorting/organizing – i.e. grooves/teeth structure, magnetism, and others), color, and enjoyment. Protrusion is chosen to be the tactile feature for people who are visually impaired. Modular has been chosen to apply on multiple organization products. The rich colors are based on the child's nature to explore the world. Enjoyment is also important in product design to catch children's attention.

4.1.3 Strategies

Based on the essential elements above, the chosen strategies are special texture for semantic triggers, and reward of self for reward mechanism. The special texture was chosen to give the parents who are visually impaired tactile feedback from the product. The reward of self was added to the product to give the child a sense of accomplishment when they do the right behavior.

For the child user, color can be a good direction from the preference angle. Based on the information above, I chose the triad color of baby blue, which can bring the good contrast for user B and more active colors for user C, see Figure 4.3.

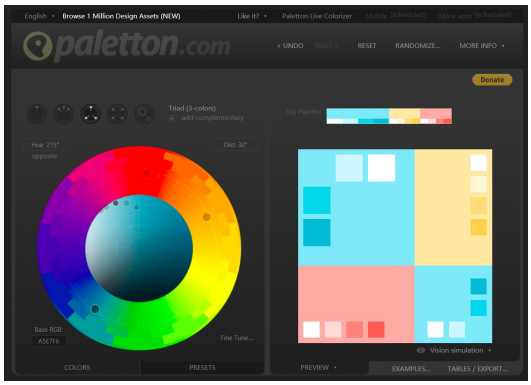


Figure 4.3 Color scheme selection (paletton.com)

4.1.4 Concept generation

Sketches

After the previous process, the project criteria for the problem is to make a modular organization product with rewards system that has easy access for parents who are visually impaired. Sketching was used to communicate concepts (see Figure 4.5). Ideas explored here included: 1) On the top left, a turntable. When the child puts one thing back, they push the button on the outside circle. When all the buttons have been pushed in, they can turn the table and get a reward. 2) On the bottom right, parents can attach that blue part on the toy. When child puts the toy back, they slide the blue attachment into slot. 3) The middle one, is a car scale which weighs the toy box. When it is full and reaches the correct weight, parts on the car pop out to inform the parents by touch. 4) On the top left, is a train toy collection, similar to 2) but the yellow attachment goes in to the train's window. The user can extend the train length based on the toy size. 5) On the bottom right, this concept is also using attachment, but this one is putting the attachment back on the shelf. The parent can touch the surface to feel if the child put the

toys back. If the child does not put the toy back, there should be holes for the attachments on the shelf.

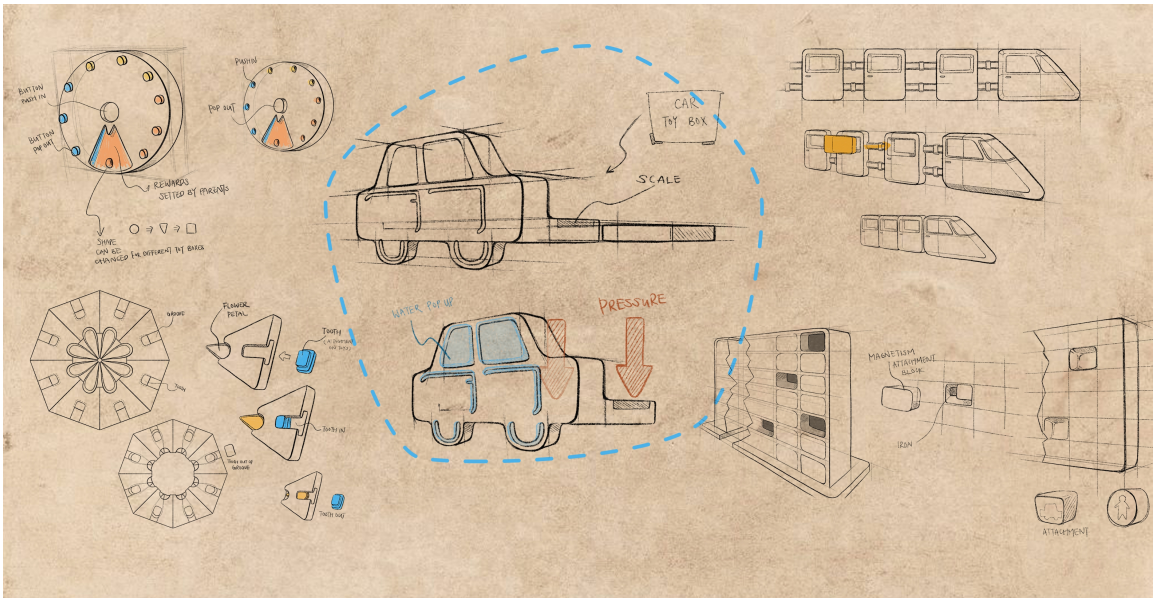


Figure 4.5 Sketches from the concept generation

After reviewing all the sketches, the car (toy) scale concept direction was chosen as it met all the strategies mentioned above. This concept uses a scale to weigh the toys that are stored in that container so that parents can know if their child put all the toys back. The weight number to make the last pop-up piece on the car scale to pop out can be re-set when parents put all the toys in the container. The details will be showed in the later renderings.

This concept is using the image of the toy types that are stored in this container/scale, in this case, the image is a car. For other sets, a doll would go on doll toy container/scale, and so on. See Figure 4.6.

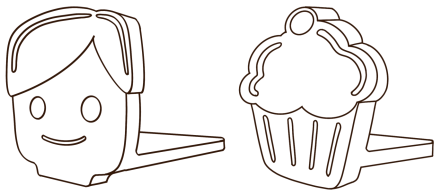


Figure 4.6 Products in the toy scales set

The CAD model and renderings below are used to visualize the car container/scale which is one of the product set, see Figure 4.7 and Figure 4.8 (product size).

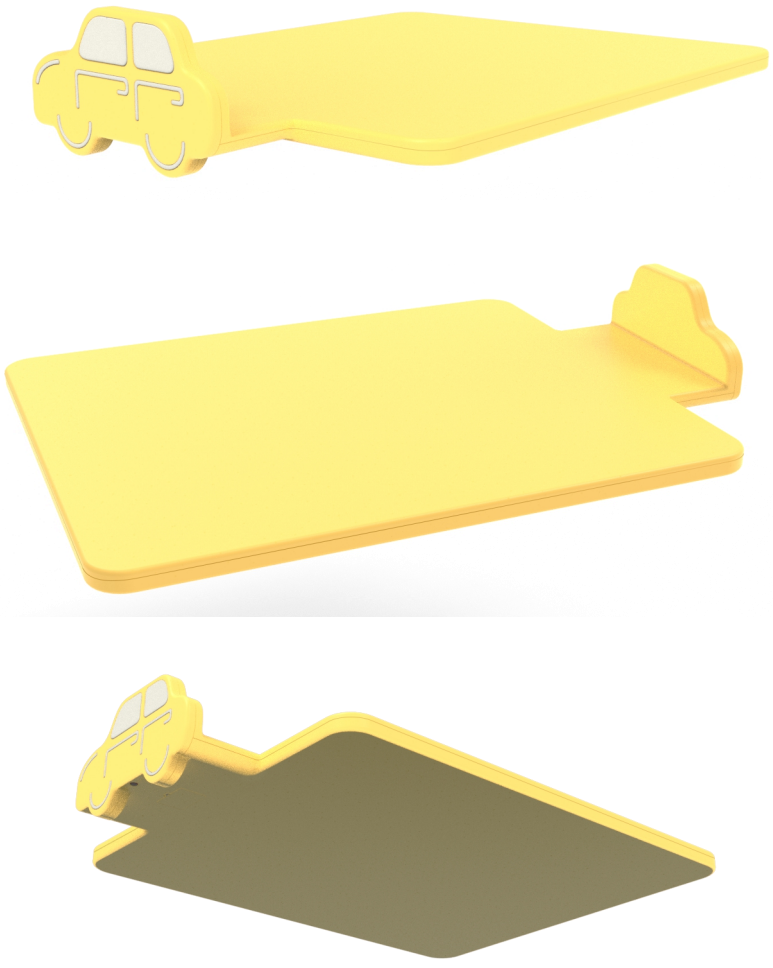
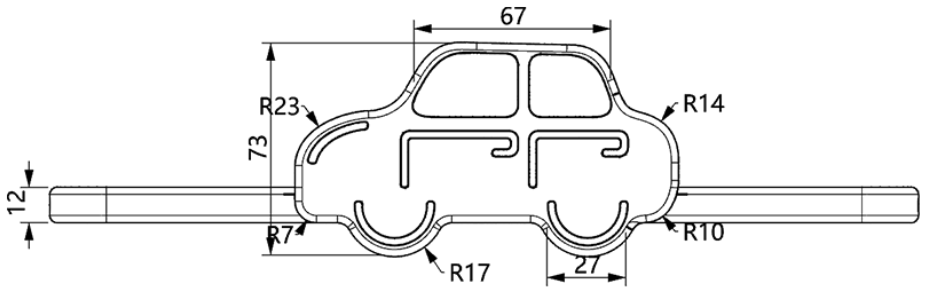


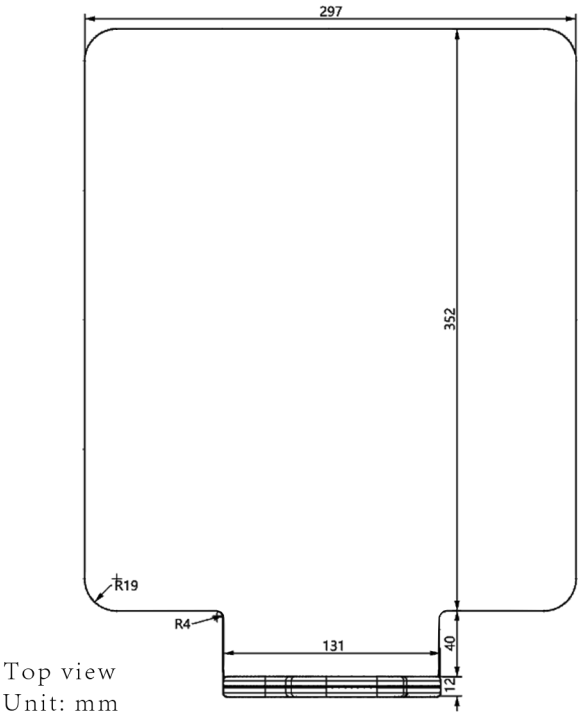
Figure 4.7 Car scale rendering

The size of this product is shown in Figure 4.8.

Right view
Unit: mm



Front view
Unit: mm



Top view
Unit: mm

Figure 4.8 Car scale product size

The scale should adhere to the surface which the users put the container on. The main product, car container/scale should also be attached to the surface. Before starting use of the car scale, parents should put all the vehicle toys in the container and put the container on the scale, see Figure 4.9. To set up the car scale, they should push the button at the bottom of the scale till the users can feel the window parts are no longer popping out to let the scale know the weight of the toys and the container.

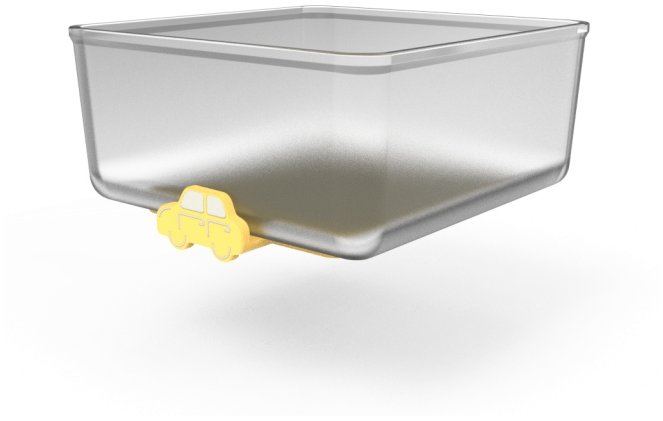


Figure 4.9 Usage of the car scale

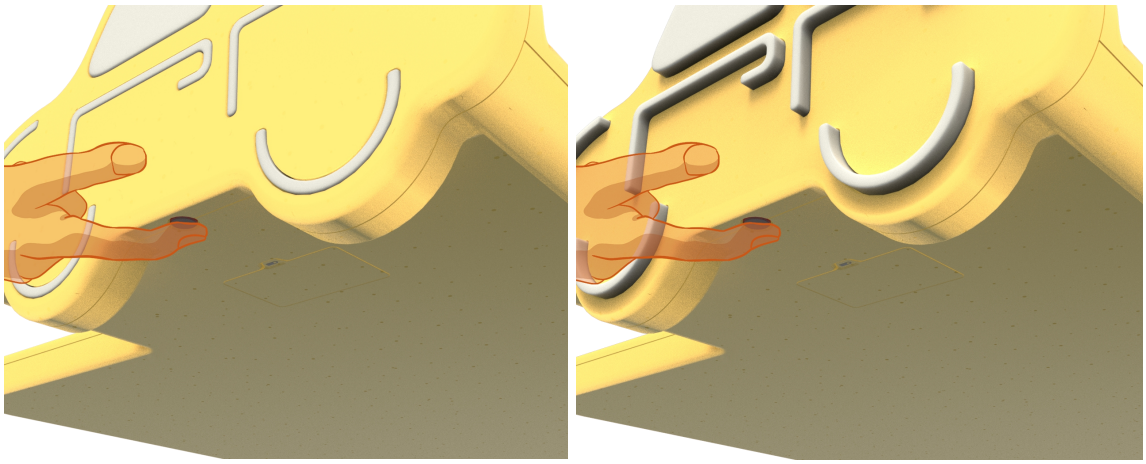


Figure 4.10 Set up the car scale (This image is just for schematic diagram of operating instructions, those hands are not in the real size)

For the first few times of using it, parents with visual impairment should teach their child the categories of the toys and help the child to learn which containers he should put the toys back into. The pop-up parts are designed to pop out according to the weight in the container. Parents can touch this indicator to know if the child has put all the toys back. If the child puts toys in the wrong container, then some containers will not have the enough weight to cause the pop-up part to pop out and parents will know that some toys are missing.

The picture below, see Figure 4.11, shows that when the toy container on the scale is empty, the surface of the car is flat. When the child starts putting a few car toys back in the container, the wheel pop-up parts started popping out. When the child put more toys back in the container, the hood and doors pop-up parts pop out. When the child put all the car toys back in the container, the window pop-up parts pop out. The parents can feel the pop-up parts to know if there are still car toys out of the container.

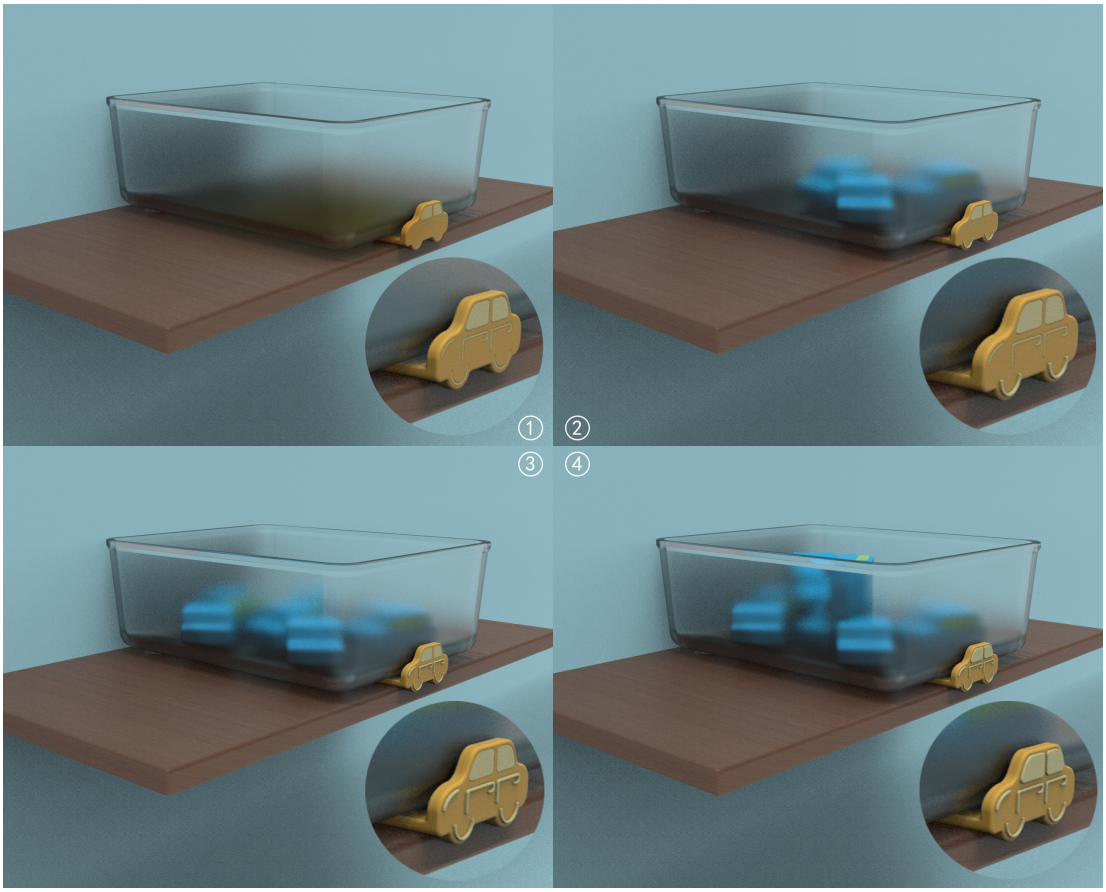


Figure 4.11 Example of the car scale and the weight

This solution is a product-based-system for helping the child to put the toy to its original location and developing the habit of putting things back, which can also reduce the chances of parents stepping on toys. It does not ensure that the child will put the correct items into the containers. Therefore, in the process of cultivating good habits, parents will need to give their child guidance and help clean up the toys together with the child in the early stage of this product's usage, teaching the child how to identify where the toys should be stored based on the iconic toy shape on the front of the container (the car container/scale in this case) and indicate to the child how this will help their parent who is visually impaired.

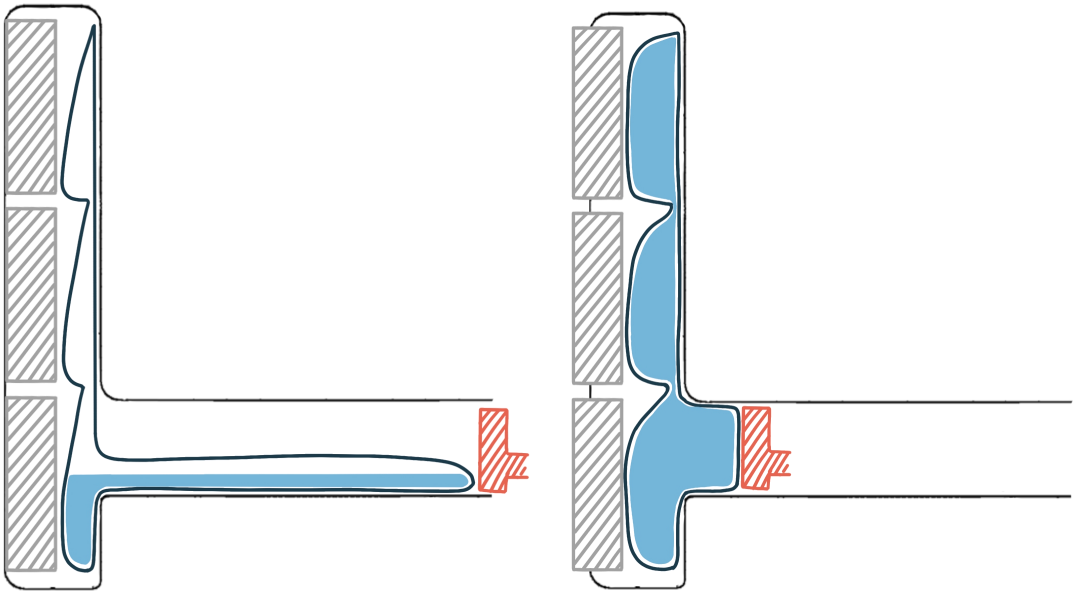


Figure 4.12 Mechanism of the pop-up parts

One potential solution for the mechanism of could be to use an internal water bag that causes the pop-up parts to push outward as a tactile example of the weight of toys in the box. When the full weight is set on the scale, the set-up chip in the scale might automatically divided the number by three, for example. This triggers a mechanical device behind the red block part in the picture above (see Figure 4.12) to push the water bag forward and the water bag will push the parts to pop out as the weight in the box increases. For example, if the total weight of the toys is 9 pounds, then when the weight reach to 3 pounds, the red block will push forward enough to let the water fill the bottom layer to push the bottom pop-up parts. Same when the weight reach to 6 pounds and 9 pounds. As toys are removed from the container, the water bag will release the pressure on the buttons and some form of spring mechanism will help them to return to their depressed position.

While this guideline was followed to create a solution that could work in this scenario, it does not ensure that the product will be successful. Designers should also consult with engineers about mechanisms, as well as engineering and manufacturing methods if it is possible. As in all normal design processes, the products developed need to be evaluated and tested. After reviewing this design, it is apparent that according to the child's character and naughty degree there are opportunities for this product to be misused (intentionally or not), which would require further iterative development. Also, other mechanisms might provide better solutions to create the tactile visualization of the weight.

4.2 Implementation 2

The second design implementation was explored using this guideline to build a healthier relationship and encourage the interactive communication between a ***husband who is losing sight with a wife who is sighted***.

4.2.1 Define the scenario and understand and empathize with users

As with the first implementation, the user's physical information, living relationship, living environment, and interactive activity need to be defined. In this case, due to acute angle-closure glaucoma, the 47-year-old husband is losing his sight in a very short period. His vision is reduced and blurry, and he often see halos around lights (Starr, 2018). His 43-year-old wife is sighted but has a little night blindness. The story about how they met is a great memory in their lives. When the husband was young, he loved the dancing machines in game centers and he met his wife in one. Now activities like operating the microwave, washing, and drying machines, identifying clothes are issues

because those things happen frequently in users' lives and the husband needs a lot of assistance. For this design implementation, operating machines is chosen as the activity to focus on because lack of understanding of each other's needs can worsen teamwork. For a man who is at his middle age and losing sight acutely, Braille will be hard for him to learn in the short term. Additionally, in the strategies discussed in the literature review, there are many things available to mark and label objects, which will be hard for a man who just lost sight to remember and operate. Therefore, a guiding system that connects with his memories can be a good direction for the outcome. The environment spaces here are kitchen and laundry room.

To define the issue, online searching, literature review and reviews of people with visual impairments' video records were the main resources to understand the target users and focused on the target users' interaction and communication while operating the machines. The users defined in this paper were compiled from those described in the literature review and other online research from these sources: "Acute angle-closure glaucoma is an emergency because if it is not treated quickly, it can lead to permanent loss of vision" (Starr, 2018) ; Tactile labels can cover the underlying visual labels to cause inconvenience to people who are sighted (Branham & Kane, 2015); The YouTube video *How I Do Things Around The Kitchen Without Sight*: dots have been stuck in the kitchen and washing machine (Cayla with a C, 2018).

The issue in this kind of activity can be defined as an *operation and labeling issue*. Following the guideline, an emotion and communication journey map was created from this research to illustrate the general process of operating the microwave and washing machine. It is separated into four sections: attempts to do the task, getting frustrated

(can't find), explaining, and completing the task (Figure 4.13). An emotion variation flow derived from this research is shown below the interaction process. The unhappy faces showed up starting when the husband realized that he couldn't find the button he needed, needed assistance from his wife, and interrupted what she was doing. Later, the husband found out he couldn't remember how to use the defrost function on the microwave and needed more help from his wife which made him more frustrated. The wife also got upset primarily because her husband couldn't do the things he could do before, and also because she has been interrupted for a while when she was working on something.

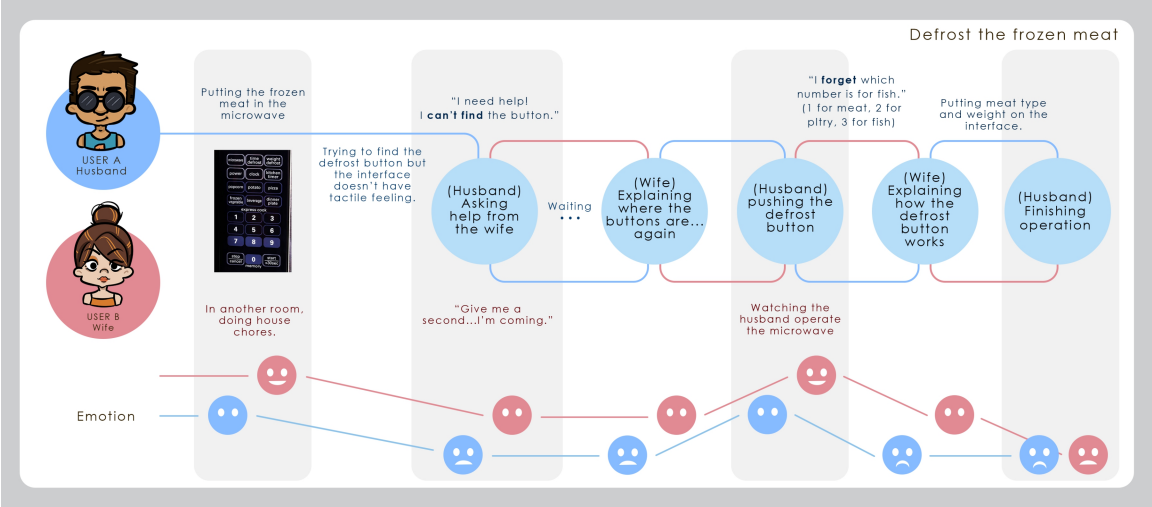


Figure 4.13 User journey map for a husband who is losing sight with a wife who is sighted

Next, more details are now needed to make the user information clearer, see Figure 4.14.

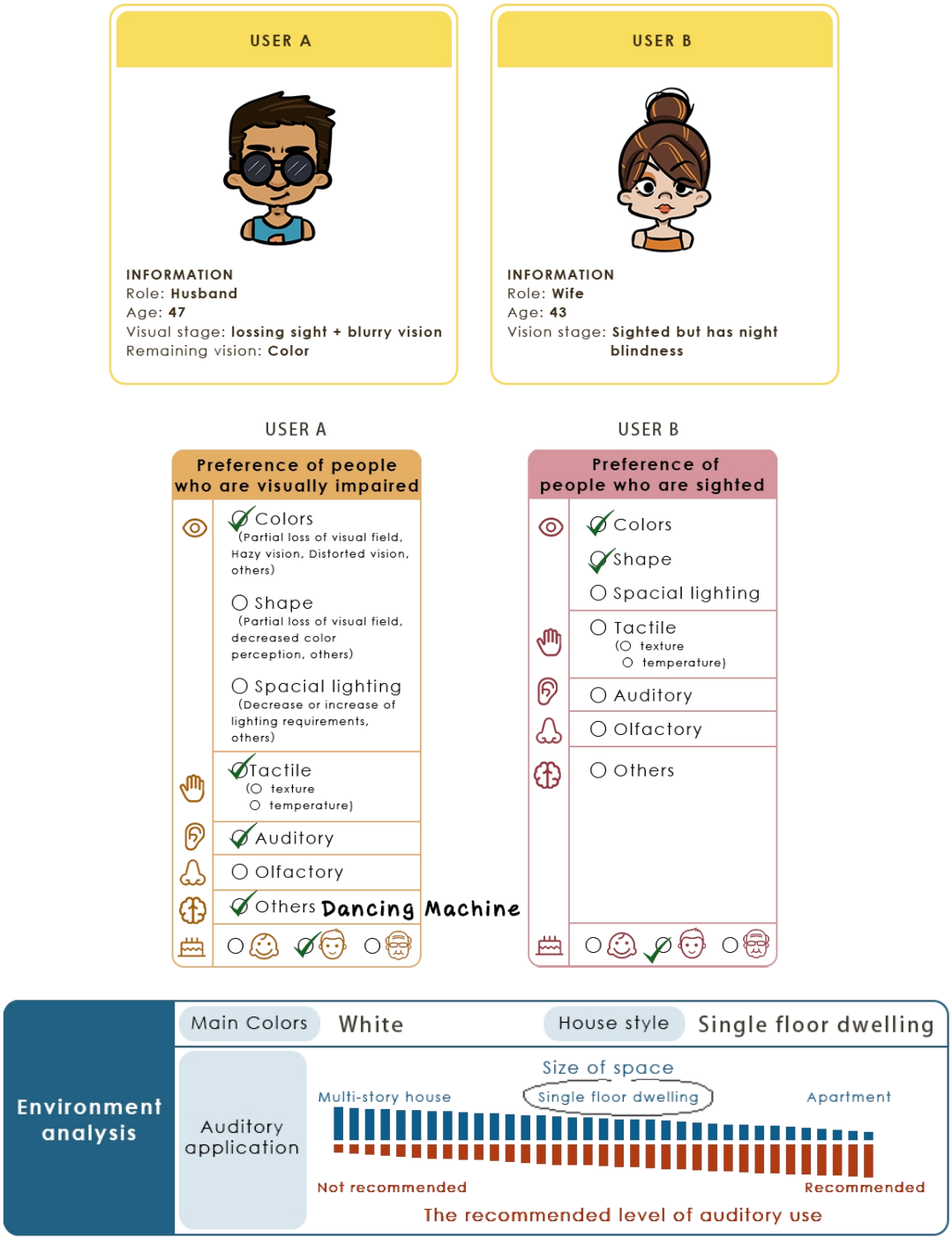


Figure 4.14 User information

4.2.2 Researching existing products

The basic information of the target users can help the designer make decisions of the product type, functions and so on. In this design implementation, the preferences of the couple here were arbitrarily chosen to show how the guideline can be implemented. According to the above knowledge, both of them prefer receiving color information and the husband who is visually impaired also prefers tactile feeling, auditory information and other memories. Based on their special memory of the dancing machine, I chose red, blue, and yellow as the main colors of the products to evoke that memory (see Figure 4.15).

Figure 4.15 Color scheme selection (paletton.com)

The existing product research is divided into three categories: products for labeling, products that have special tactile features for people who are visually impaired, and products related to identifying (see Figure 4.16).

Figure 4.16 Existing Product Research

1 PenFriend III, n.d.

2 Burns, 2008

3 Seth, 2009

4 Mitra, 2020

5 Fatimah & Zia, 2021

6 Mitra, 2020

7 Mitra, 2020

8 Tran, 2008

9 Mitra, 2020

10 Turner, 2016

There are three essential elements towards the design of products that have been abstracted from users and existing product research: tactile, color (transformation label, Lego blocks, color detector), and technology (wire tag/tracer). Tactile is for the husband who is visually impaired because it is a very popular way for people with visual impairment to distinguish objects. However, Braille will not fit in this case due to the husband's sudden vision loss and the fact that it takes time to learn Braille. Color is also a good solution for people with visual impairment who can still see colors to figure out the different stages of an object or distinguish the objects. Technology can also be applied to products, but the cost will be relatively higher.

4.2.3 Strategies

Based on the essential elements above, the chosen strategies are special texture, evoking memories of wonderful times, social-esteem for semantic triggers, and shared language for understanding of each other. The special texture was chosen to give the husband who is visually impaired tactile feedback from the product. Using evoking memories of wonderful times as a trigger can bring positive energy to their lives. For social-esteem, this product can be designed to have custom usages to show users' tastes. The shared language was added to the product to help the couple to understand each other's requirements.

4.2.4 Concept generation

Sketches

After the previous process, the project criteria for the problem is to make a label system with shared language that has easy access for the husband who is visually impaired and the wife who is sighted. Sketching was used to create concepts (see Figure 4.17). Ideas explored here included: 1) On the top left, the dots around the center turning machine. By setting up the names of the dots on the phone, when the users turn the center block and let the metal piece touches the dot, the phone will say the previously set command. 2) On the top right, is a chessboard with plenty of holes that allow users to make customized label tapes. 3) On the bottom left is a series of colored blocks, for which the user can use a color-detector-based speaking pen to tell users what the words they previously set for the colors. 4) On the bottom right, users can refill the "stamp"

maker like the mechanical pencil, and push the blade at the bottom, cut the sticks, and stick the dots on the surfaces.

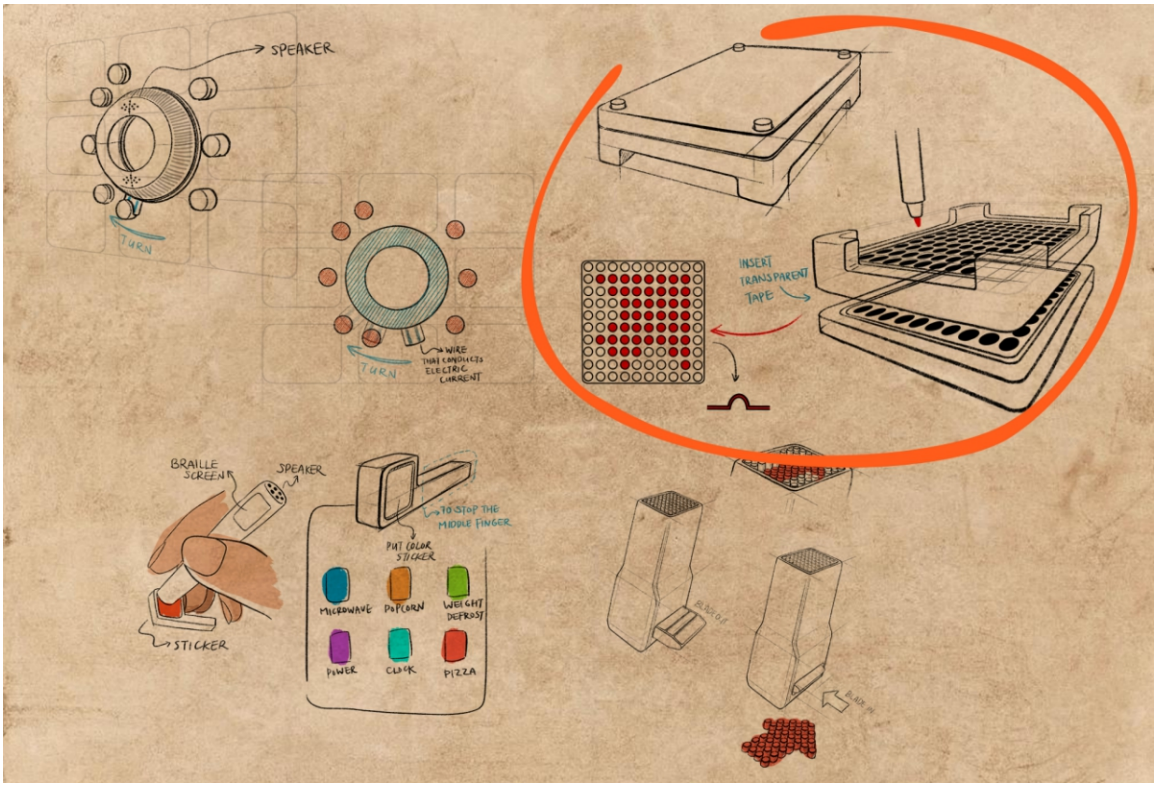


Figure 4.17 Sketches from the concept generation

Figure 4.18 Vrailler's Braille Printer (Mitra, 2020)

After reviewing all the sketches, the Tactile Chessboard concept was chosen as it met all the strategies mentioned above. This concept is inspired by the Vrailler's Braille Printer, which can only print braille, seen in Figure 4.18. This concept uses a box with a chessboard-like top with 100 holes on it. Users put the transparent tape between the lid and base. Then they flip the product, and use a pen dipped in pigment (pigments need to contain phosphors) to poke the hole and make embossed patterns on the tape. The users can see which hole they poked from the top transparent part of the lid. The pattern can be customized by a designer or a user. The details will be shown in the later renderings.

This concept can be achieved by 3D printing for the main body part and ethoxyline resin for the transparent part.

This concept is using the user's imagination and creativeness of the pattern design. For example, in this case: creating labels for microwave, the five patterns (arrow patterns of 'top left, top right, center, bottom left, and bottom right') from the dancing machine can be used to label and locate the number buttons on the microwave. The CAD model and renderings below are used to visualize the product, as shown in Figure 4.19 and Figure 4.20 (product size).

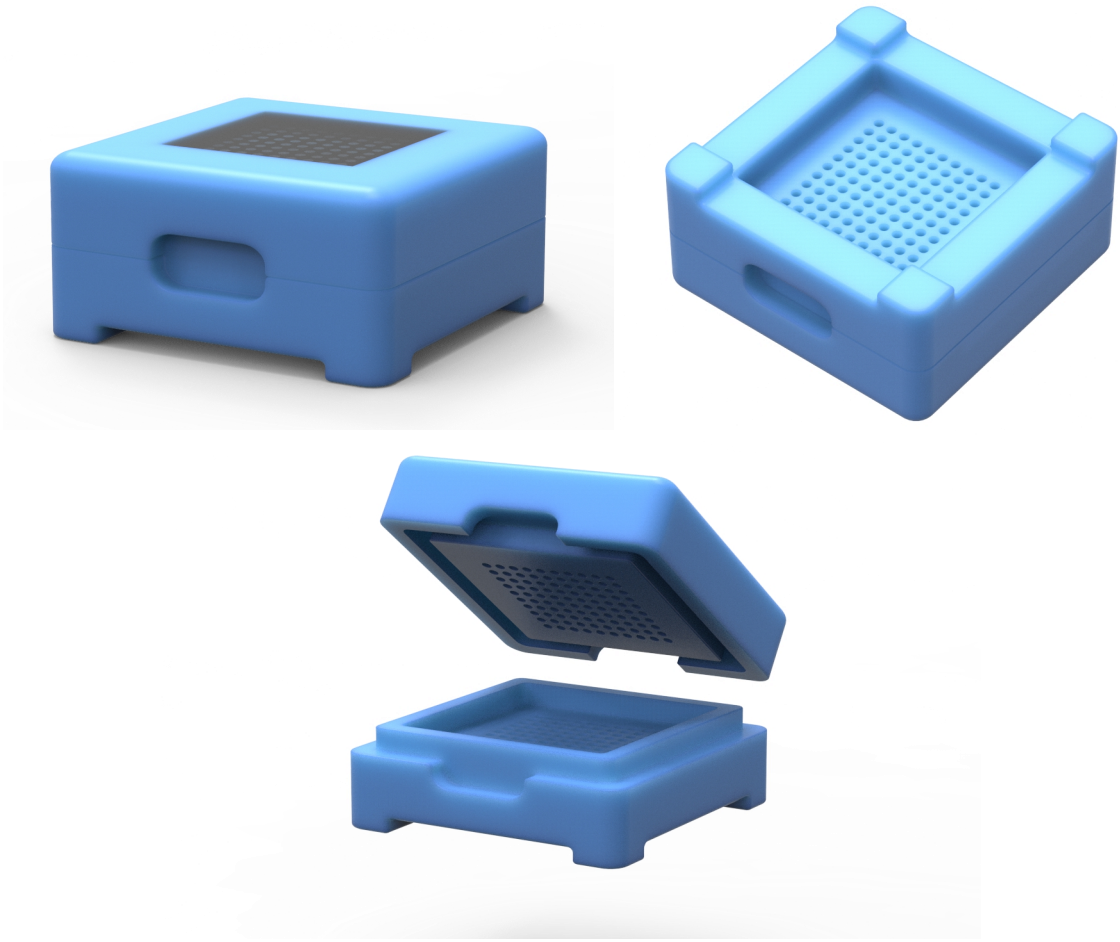


Figure 4.19 Tactile chessboard product rendering

Below is the size of the product (see Figure 4.20).

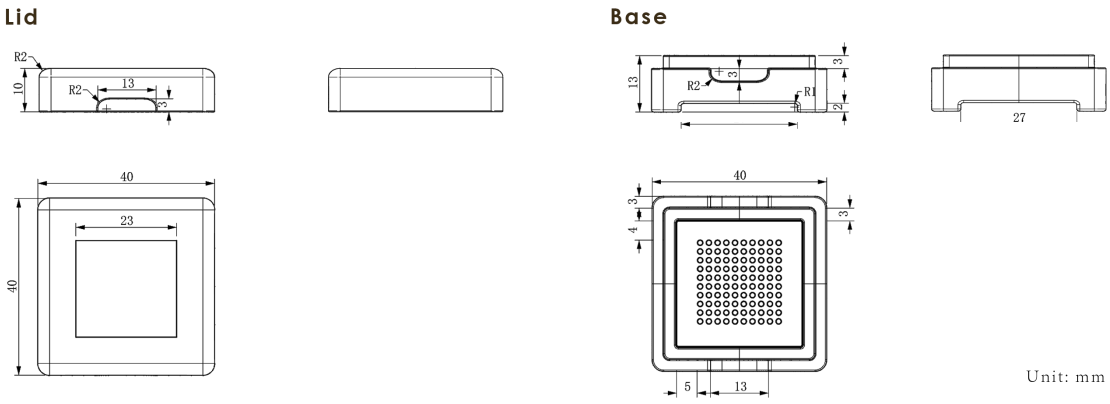


Figure 4.20 Tactile chessboard product size

When they want to create a new label, the husband and wife need to discuss which pattern can be suitable for both, for example, the pattern from the dancing machine that created a joyful memory. Then wife can put the tape between the lid and base, close the lid and base to hold the tape. They can then put the pen in pigment and poke the holes on the chessboard to create a embossed pattern on the tape, see Figure 4.21.

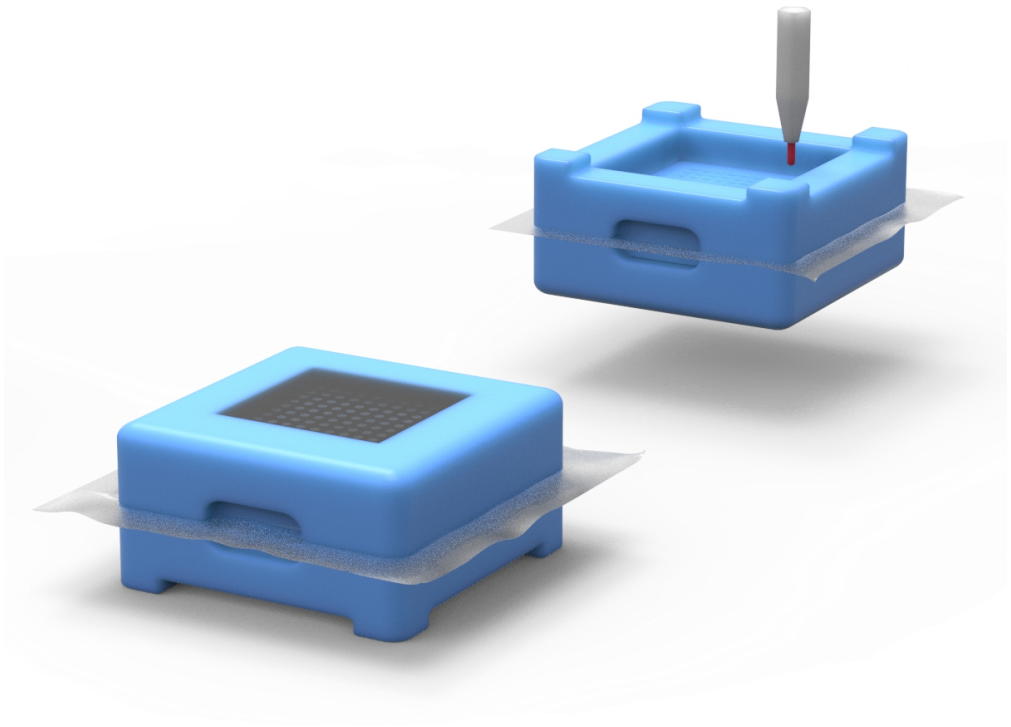


Figure 4.21 Usage of the tactile chessboard

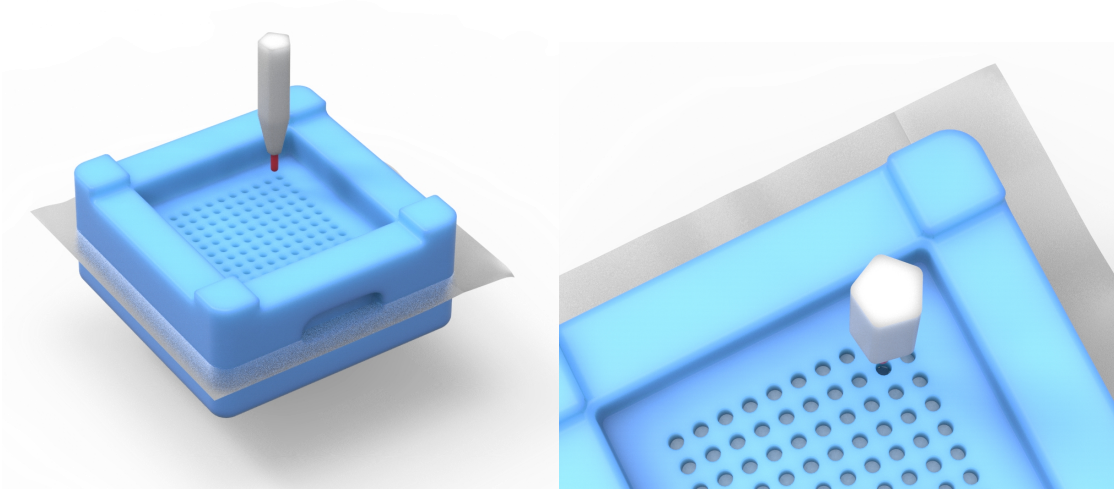


Figure 4.22 Creating the pattern

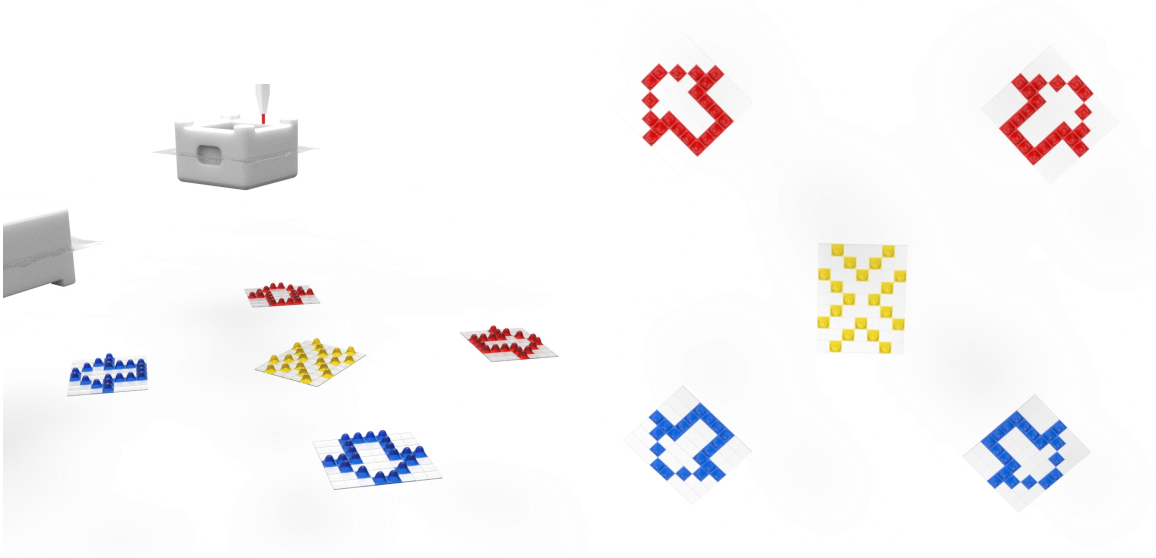


Figure 4.23 Example of the embossed pattern

Figure 4.24 Application of the tape

Like the example in Figure 4.24, different patterns can also be created to apply on a washing machine, a dryer and other product interfaces to help people with visual impairment to locate buttons, distinguish the functions and remember the operations.

To create the pattern for the label, use the erasable light color to draw the sketch on the blank sample, then use darker color to make out the hole where the sketch is, and erase the sketch. Next use the instruction on the paper the user just made as a guide to pop out the tape through the chessboard holes and make the embossed label. See Figure 3.25.

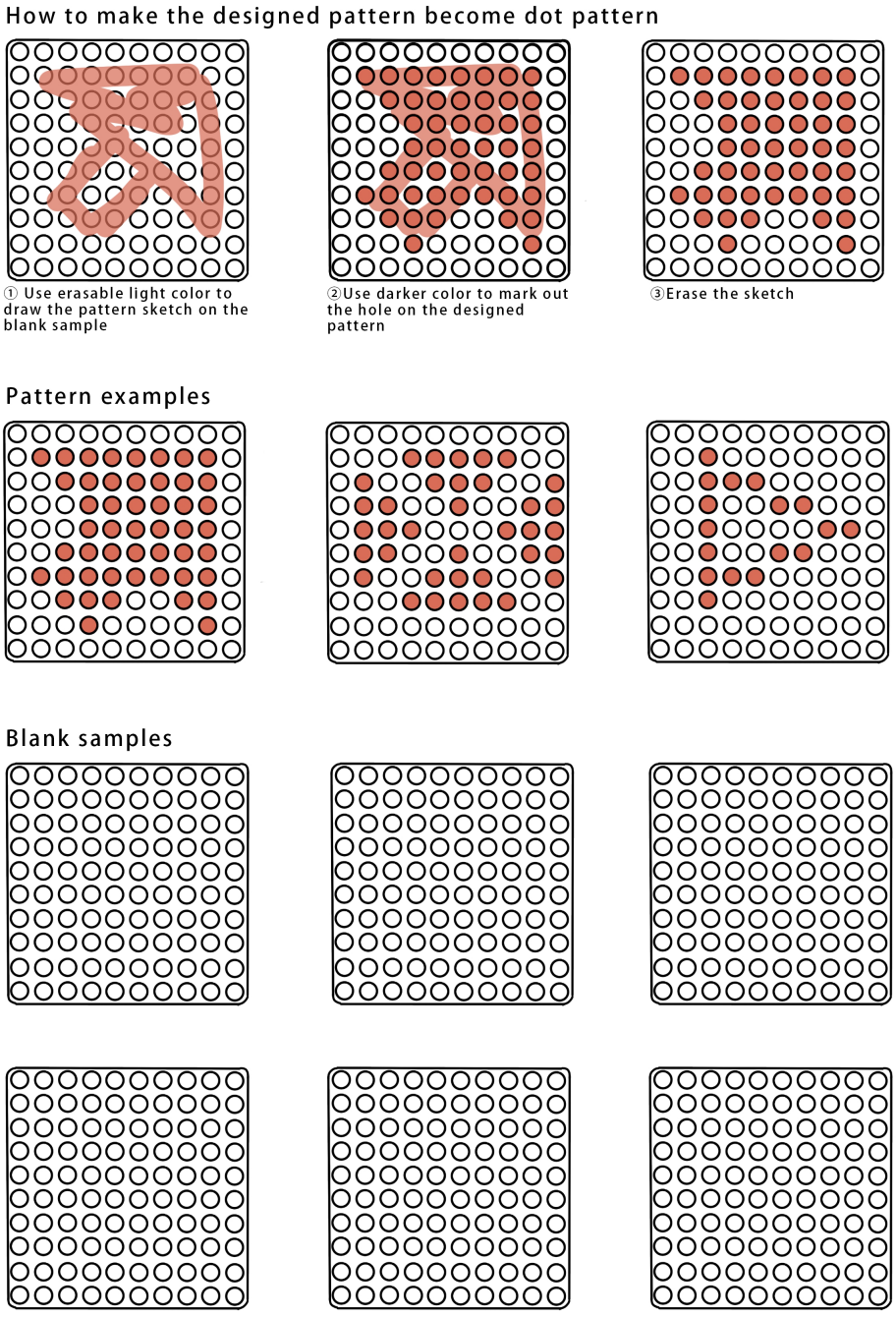


Figure 4.25 Instruction, examples and blank sample for creating an embossed label

This solution is a product-based-system for helping the couple to create a labeling system in their living environment. By creating different patterns, they can create labels to distinguish clothes, objects in the kitchen and other things in the household.

While this guideline was followed to create a solution that could work in this scenario, it does not ensure that the product will be successful. As in all normal design processes, the products developed need to be evaluated and tested. After reviewing this design, it is apparent that according to the users' creativeness and other abilities there are opportunities for this product to be misused (intentionally or not), which would require further iterative development.

Chapter 5 Conclusion

Designing with understanding and enhancing collaboration is proposed in this thesis, which can help designers to have a better understanding of people with visual impairment and people with sight who cohabit, and design products based on their pain points to promote interactions and communications at home.

In the literature review, I explored the statistics of low vision in America, categories of remaining vision, senses other than vision that have been used to help people with visual impairment to live their life, challenges and needs of both people with visual impairment and with sight, the objective and subjective struggles people with sight are facing, the misunderstanding from people who are sighted that can cause more inconvenience to people with visual impairment, the slight differences between different relationships of people with and without visual impairment, the strategies that have been used in the lives of people with visual impairment, and the elements that can help to assist the cooperation between the users. By understanding the physical condition of people with visual impairment, understanding the challenges and needs of both groups (not just only focusing on people with visual impairment) can really help designers to understand the problems and find the pain points. By knowing more about the strategies that have been used for people with visual impairment, designers can have a general idea of what they can use and what they should avoid on their products.

This guideline can be used by professional industrial designers and industrial design students who already have a general idea of typical design process. This guideline includes five steps: 1) Discover, 2) Define (the problem), 3) Strategies, 4) Prototype and 5) Test. Steps 1 and 2 are the most important compared to the typical product design process, which can help designers to have a deep understanding of the abilities, needs, preferences and other information of both user groups. Step 3 is unique from other product design processes to help designers to develop features for their specific user groups to collaborate. Different charts and check lists were also created to help designers to collect information and analyze it. As shown in the two examples in the design implementation chapter, this guideline was used to create a product to help the child with sight to collect toys and develop a new habit at the same time to help the parents who are visually impaired live easier (without tripping over toys out of place). A label making product was also developed for a partner in a couple who just lost sight to locate and distinguish the buttons. However, in the first implementation, the child may put wrong objects back in the toy box and confuse the parents who are visually impaired. For situations like that, designers should feel comfortable to adjust their procedures or they can go back to repeat the last a few steps to create a better solution according to practical conditions. Design results may vary depending on the designers' and the users' cultural backgrounds, values, cognition and so on. As more design applications are created using this guideline, the strategies can be refined into more categories and be extended to fit a wider range of user groups.

Following the thought of this paper, by exploring the physical information, challenges, needs and struggles of the user group, and the strategies that have been

proven to work for the users' lives, this design guideline could be further expanded in the future through a similar information collection process and be applied to people with different disabilities other than visual impairment.

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