DESIGNING AN ASSISTIVE TECHNOLOGY FOR A TRANSGENERATIONAL POPULATION: THE PRODUCT DEVELOPMENT PROCESS

BY

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THESIS

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ABSTRACT

It is a fact that most people will forget to take their dose on time due to time pressure, multi-tasking, amnesia etc. Considering people’s age, the problem will become more severe due to the increased number of medications prescribed by doctors and the differing frequency they have to take each of those medications per day. An additional encumbrance on top of keeping track of each of the doses is a person’s disability such as impaired hearing, vision and memory. While there are a large number of pill organizers on the market, they are either too large with complex computer-aided systems or too simple without enough accommodating functions. The value of this thesis is that a portable pill dispenser and reminder with simple but intuitive interface will be developed to assist medication users while they are unable to access their home pill dispenser because of working, traveling and outdoor activity.

Keyword: medication management, pill dispenser and reminder, portable, user interface, universal design
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1.1 Why design a pill dispenser?

Pill dispensers are items which release medication at specified times. Their purpose is to help senior citizens and other people who may suffer from an impaired memory to keep track of medication intake (“pill dispenser”, 2010). The definition from Wikipedia (2010) is basically accurate, but the usability of pill dispensers is not limited to older adults or those with impaired memory, but to any and all users that need manage complex medicines regimes. Having to take many medicines on a daily basis is cognitively complex/demanding task because medication users have to develop a plan for which medications to take when (which often involves satisfying multiple constraints such as which meds to take together, which with food, some cannot be taken near bedtime, etc), and then implement the plan (remembering to take at right times). Figure 1.1 is some pill dispensers currently on the market.
Figure 1.1: Pill dispensers currently on the market

Pill management is a popular topic discussed by a lot of experts in the medical industry. The following paragraph explains why pill dispensers are important to medication users.

It is a fact of life; without constant medication reminders, everyone forgets to take a dose at one time or another. But as people grow older, the list of medications prescribed by their doctors grows and the number of times per day they have to think about it multiplies. For a growing number of Americans unaware of medication management, forgetting a medication dose or taking the wrong dose can threaten both health and quality of life. This failure to follow the doctors' prescribed orders is what the medical community calls “non-compliance” or, more recently, “non-adherence”. Both of these terms mean the same thing: that the patient is not properly following a prescription or
medication management regimen. In a 2007 survey of 17,000 Medicare beneficiaries, two out of five seniors reported taking five or more prescription medications.

According to the New England Journal of Medicine, costs associated with this non-adherence range upward of $1 billion annually in hospital costs. And the FDA estimates that more than two million serious adverse drug reactions occur each year, reporting that adverse drug reactions are the fourth-leading cause of death, responsible annually for about 100,000 deaths (Orlov, 2010).

1.2 Why make a portable version?

a. Products currently available in the market usually have several pill containers with very complex computer-aided interfaces, which could dispense pills for a lot of days. On the downside of this functionality, those pill dispensers lose portability due to relatively large physical dimensions. People however, do have a need to travel at certain times even if they are senior citizens or impaired in any way. They may want to travel or enjoy outdoor activities which demand a portable device to manage their pills while they are not able to access their pill dispensers at home.

b. While there are some portable drug organizers on the current market, many of them accurately approach only one aspect of the pill dispensing process; leaving the patient to do the rest of the work as pictures show below.
Pill dispenser on the left in Figure 1.2 has a reminder to help people take their dose on time, but it only has three pill containers which means it can only dispense pills up to three times before having to be reloaded for the next interval. Also this device does not consist of a pill-splitter to satisfy the needs of medication users to take half a dose. In addition, the interface of this device does not provide enough information about the pills in the dispenser. The pill dispenser on the right in Figure 1.2 is a pill-splitter which can only cut pill tablets into halves, but it does not have the function to dispense medication to patients. Due to the disadvantages and limitations stated above, the author of this paper would like to focus on developing a portable pill dispenser accommodating necessary functions, which is also with simple but intuitive interfaces usable for all people.
1.3 A medication user study

First, there are some statistics listed below about medication users (Startling Statistics About Seniors and Medication Use, 2008):

- 32 million Americans are taking three or more medications daily.
- The No.1 problem in treating illness today is patients' failure to take prescription medications correctly, regardless of patient age.
- 75% of older adults take one or more Rx drugs.
- 25% of older adults take five or more meds on a regular basis (28% of women and 22% of men).
- “A fifth of [Medicare] beneficiaries have five or more chronic conditions and account for nearly two-thirds of Medicare spending. … beneficiaries with five or more conditions fill an average of forty-nine prescriptions in a year, have an average of thirty-seven physician visits, see fourteen different or unique physicians in a year, and log more than 7,000 inpatient days per 1,000 people.” (Berenson and Horvath, 2003)

As stated in the data above, 32 million people take more than three medications daily which means that as people age, the number of medications prescribed by doctors keep increasing. Ultimately, the greatest problem is failing to take those prescription medications correctly. For senior people specifically, since they are more likely to have memory impairment and/or physical limitations, they will have increased difficulty
adhering to a medication regimen. Although, there are many factors may cause nonadherence, it partially reflects failure to understand how to take medications and remembering to do so, which needs to be solved by new design solution of pill dispenser in further progress. In addition, a lot of medicines have complex procedures and requirements to follow which may also lead to mistakes in taking medication by the patients. The Figure 1.3 below is some labels of drugs which show related information of medication.

![Figure 1.3: Medication labels](image)

Also, the author of this paper had been to CVS pharmacies to do research about medicines on the current market. The picture below shows some instructions of different kinds of medicines.
From current product research, most medicines need to be taken “one, two and three times daily.” This means patients usually need to take medicines every four or six hours. Also, some medicines give a clear indication to be taken before or after every meal.

1.4 Target user group

Usually the purpose of a pill dispenser is to help people manage their drugs and adhere to their pill regime while also being helpful for seniors or people who suffer from memory impairment. In this thesis, a portable dispenser which can satisfy the needs of all medication users including senior citizens and impaired users was developed. The target group of this pill dispenser is anyone that is taking medication and is in need of a device to assist them to manage their medicines while they are unavailable to access their pill dispensers at home. There are two distinct sub groups listed below for further research.

a. Seniors patients who are temporarily unavailable to use pill dispenser at home such
Figure 1.5: Senior medication users

Based on previous research, seniors are a very specific and important group of medication users to consider. It is not only because they take more prescribed medicines but also their ability impairment such as hearing and vision impairment or grip problems. Considering universal design (which is also discussed in Chapter 5), it is possible to provide a portable pill dispenser solution without specialized design which could be used by all medication users including seniors citizens.

b. Pill dispenser users who travel frequently

Figure 1.6: Medication users who travel a lot
From a report of the American Society of Consultant Pharmacists (2008), it contains some data listed below:

- 51% of all insured Americans take at least one prescription drug.

  20% of insured Americans take three or more Rx drugs.

  (Startling Statistics About Seniors and Medication Use, 2008)

It is obvious that not only senior Americans take prescription drugs by looking at this data. Some of these medication users may also travel frequently due to their work so they will need a portable device which can manage their medicines and remind them to take the correct dose on time. How to make the new design solution convenient for people who travel a lot? It becomes an issue to be addressed in the further development.
CHAPTER 2: BACKGROUND

2.1 What is medication management?

To health professionals like doctors, nurses and pharmacists, medication management
is helping them give their patients the appropriate treatment choices. To patients,
medication management is to help them to understand their medications and take their
medications correctly. The discussion above is very general, the list below are some
detailed benefits from medication management:

1. Providing information on new medical treatments to health professionals
2. Helping medication users take their medications correctly
3. Helping patients to understand what kind of harm may caused by side effects
4. Developing local guidelines for managing conditions
5. Helping patients communicate with their doctors and pharmacists
6. Helping patients store their medications correctly

A pill dispenser is an assistive device for medication users to manage their drugs; it
helps users take the right dose of medicines at the right time. Also some pill dispensers
on the market have combined a reminder to remind people take medicines at certain
time.
2.2 Change of processing in aging

It is common knowledge that people go through a lot of physical and mental changes such as vision impairment, hearing impairment and memory loss when they age. For a person's vision, aging can decrease the speed and accuracy of recognizing objects or movement. In addition, it impairs the ability of people to comprehend and recognize complex systems or mechanisms. These changes due to aging can be proved by Figure 2.1 and Figure 2.2.

Figure 2.1: A model of human information processing stages (Wickens and Hollands, 2000)

Figure 2.2: Age-related Gains versus Declines (adopted from Park, et al. 1996)
Sensor Processing located on far left of IP model is the stage of receiving information using sensory receptors, such as eyes and one of the parts that slows with age. As mentioned several times earlier, aging is accompanied by decreased vision ability in many cases. For example, lenses get more yellow and opaque, and less light reaches the retina. Therefore visual acuity (ability to identify details) declines, which will increase problem reading small print for aging people. Also, hearing ability and tactile sense also become less sensitive with age. For instance, the ability to hear high frequencies declines for aging people, which may cause a problem for beeping reminders on devices. There are also age declines in cognitive resources, such as speed of processing and working memory. However, age related increases in experience may translate into greater knowledge, which may compensate for these age-related sensory and cognitive declines (Morrow, 2008).
3.1 What is the simulation of a medication user?

After the preliminary study of medication users, a medication user simulation experiment was developed to get a deeper understanding of the patient condition and to experience the difficulty in using a pill dispenser and pill reminder. The medication user simulation is a human-centered design approach for further product development. This simulation is very similar to empathic modeling. The empathic model is a technique used to simulate age-related sensory losses to give designers personal experience with how their product performs for users (Suri, Battarbee, and Koskinen, 2005). In the following research, the author of this paper will simulate a user of medication by taking the prescribed medicines below with some pill dispensers and pill reminders that are available on the current market. The ease/difficulty of use, absence of a dose and any incorrect dosage or errors will be written down for further study.
**Table: Medication Schedule**

<table>
<thead>
<tr>
<th>Drug name</th>
<th>This looks like</th>
<th>How many</th>
<th>How I take it</th>
<th>I started taking this on</th>
<th>I stop taking this on</th>
<th>Why I take it</th>
<th>Who told me to take it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tylenol</td>
<td></td>
<td>2</td>
<td>Can be taken with or without food</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronkaid dual action formula coated caplets</td>
<td></td>
<td>1</td>
<td>With or between meals</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>In the afternoon, I take:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tylenol</td>
<td></td>
<td>2</td>
<td>Can be taken with or without food</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BYSTOLIC</td>
<td></td>
<td>1</td>
<td>Can be taken with or without food</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronkaid dual action formula coated caplets</td>
<td></td>
<td>1</td>
<td>With or between meals</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B</td>
<td></td>
<td>1</td>
<td></td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>In the evening, I take:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tylenol</td>
<td></td>
<td>2</td>
<td>Can be taken with or without food</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronkaid dual action formula coated caplets</td>
<td></td>
<td>1</td>
<td>With or between meals</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Before I go to bed, I take:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B</td>
<td></td>
<td>1</td>
<td></td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronkaid dual action formula coated caplets</td>
<td></td>
<td>1</td>
<td>With or between meals</td>
<td>Feb 2nd</td>
<td>Feb 9th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other medicines that I do not use every day:**

---

**Figure 3.1:** Simulating medication schedule

**Figure 3.2:** Medicines for simulation

**Figure 3.2** above is the medicines used in this test. The names and instructions are listed below:

**Tablets for hypertension**

Medication name: **BYSTOLIC**

Offers convenient once-daily dosing
Can be taken with or without food.

Can be taken alone or in combination with other high blood pressure medications.

**Tablets for headaches**

Medication name: Tylenol

Two tablets every 4-6 hours

Do not exceed 12 (product) in any 24-hour period.

**Solution for colds**

Medication name: Bronkaid dual action formula coated caplets

1 caplet every 4 hours not to exceed 6 caplets in 24 hours

With or between meals

**Vitamins**

Medication name: Vitamin B

1-2 tablets, once daily

With or between meals

![Figure 3.3: Simulation of medication user](image)

Figure 3.3 shows the simulation process conducted by the author of this paper, and the
simulation equipment for this thesis are a seven-day pill dispenser, a travel dispenser, a pill reminder, four different kinds of medicines and a pill medicine schedule. The simulation was conducted by the designer of the thesis. The designer would take medicines by the schedule of medicine in Figure 3.1, and the author of thesis will also follow a normal schedule of aging people to make this experiment accurate. Through simulation, the designer would not only gain in customers’ feelings but also find the difficulties while using the pill dispensers.

3.2 The experience with pill dispenser

Pictures below are two typical portable pill dispensers currently on the market:

**Portable pill dispenser I**

![Stackable pill dispenser](image)

Figure 3.4: Stackable pill dispenser

The picture above is a seven-day stackable pill dispenser. It has multi-color
compartments to help with organizing medication and other small items. This product is very convenient for travel, which you can choose any number of components to stack with. The designer of the thesis conducted a simulation experiment with medicines shown in last section and will try to take the medicines on time based on medicine time schedule.

The chart below shows a brief summary of using difficulties from the medication users simulation conducted by author.

To summarize:

- No pill-splitting function
- No instruction of pills
- No pills order indication

**Portable pill dispenser II**

Figure 3.5: Travel pill dispenser
The simulation experiment was also conducted by author to gain in more experience with the travel pill dispenser in Figure 3.5. The travel pill dispenser in Figure 3.5 has some features: color coded for daytime and nighttime use, lightweight and compact organization for vitamins and medications, and easy to use slide-locking closures keep contents secure.

From the simulation experiment, the author found some advantages and disadvantages of this product.

To summarize:

- No pill-splitting function
- No pill order indication
- Good portability
- Good readability of labels

3.3 The experience with pill reminder

![Pill dispenser and reminder](image)

Figure 3.6: Pill dispenser and reminder
Figure 3.6 is a product with a pill dispenser and pill reminder combined. It has several very unique features: easy to read raised letters and Braille markings, large digital readout and back light - aids to daily living, and reminder clock and timer * 7 compartments.

From the simulation experiments, the author found some difficulties listed below.

- No pill-splitting function
- No pills order indication.
- Sub-cases are not stackable, so users cannot decide how many cases they want.
- Clock reminder does not work when it is away from users.

3.4 Summary of simulation of medication user

From the experience of a medication user, several difficulties were found for the travel pill dispenser and pill reminder. The most obvious problem is that portable pill dispensers on the current market cannot address all the patient difficulties especially for aging patients, patients with disabilities, and patients who have several different kinds of medicine to take. For instance, firstly, most dispensers do not have a function for cutting pills into half, so they could not dispense half tablet and half doses which is a very common in doctors’ prescription. Secondly, some pill dispensers are stackable, and they are usually designed for 7-days or one month, but patients cannot customize the number of units and number of days they want. Thirdly, there are no dispensers that give an indication of order for the pills. This is problematic since there are several kinds
of pills that should be taken in a specific order. Fourthly, there are not obvious visual

cues to help aging people and people with disabilities to differentiate the kinds of
medicines. Lastly, it is a tricky problem to provide key information of different kinds of
medicines because medicine instruction tag on the pill bottles usually contains too
much information just like in Figure 3.7. Below, the drug facts label contains too much
information for medication user to read carefully.

In this paper, the aim is to provide a single device which is not only simple but also fully
addresses modern patients' varying needs.

Figure 3.7: Pill instructions
CHAPTER 4 IN-DEPTH INTERVIEW

4.1 Description

In order to define the problems of the pill dispensers and reminders more accurately, interviews were conducted by the author of this paper with some pharmacists and medication users. Also all interviews were conducted using pill dispensers to get precise information regarding usability.

A. Interviews with pharmacists in CVS, Justin and Emily were conducted. The aim is to find what types of pill dispensers most medication users like to purchase and what kind of questions frequently asked by medication users about pill dispensers. Both of two pharmacists have over ten years experience in pharmacy industry.

B. Interviews with a medication user to cover questions about the preference of different types of pill dispensers and reminders, questions about the user interface of those devices, and shadowing process of using from medication user. The author of this paper aims to do research on the interaction between the pill dispenser and reminder and the medication users in order to find the common difficulties a user experiences with the pill dispenser and pill reminder.
4.2 Information elicit in interviews

Katie is a 67-year-old aging woman that has amyotrophy. This condition causes pain and loss of muscle strength. She also has muscle degeneration and vision impairment. Katie has two daughters that take turns to live with her and help her manage her medicine every day so Katie does not have a pill dispenser at home. However she said she would like to try a portable dispenser while she travels from one daughter’s home to the other's home. Due to her vision impairment, she has difficulties with complex user interfaces of the products. She really likes to use products with simple user interfaces to help her. Some experiments were also conducted with the portable pill dispensers in regard to her vision.

Jackson is 48-years-old and does marketing in a mobile company. He has blood pressure medication to take every day so he wants a device that will dispense his medication as well as keep the medication dispenser discrete as he has to work with clients. From practicing with pill dispensers listed in previous chapter, Jackson found some difficulties to distinguish different kinds of pills in the compartment of pill dispenser. Also, he indicated that the reminder in pill dispensers currently on the market could only work in the situation medication users carry the pill dispenser with them all the time. Usually, the size of pill dispensers on the currently market are too big to take them conveniently. Furthermore, Jackson said it was difficult to tell which pills should be taken if medicines are not put into different individual compartments.
CHAPTER 5: DESIGN GUIDELINES

5.1 Study of the conventional user interface

- Computer-aided pill dispenser

Figure 5.1: Computer-aided pill dispenser

Figure 5.1 shows an interface of a computer-aided pill dispenser and reminder. From previous research of products currently on the market, the product above is a very typical computer-aided one which contains most functions patients need. This product is a daily pill dispenser and pill reminder for use in the home. It has four bins for four different kinds of drugs which has independent labels to indicate the names of the drugs. All the labels have white backgrounds with the drug names printed in black.

Furthermore, at the control panels, there is a rectangular screen that shows simple
medicine instructions when a specific kind of drug is dispensed from one of the bins. As for the reminder system, this pill dispenser and reminder has two ways of helping users adhere to their medications' schedule. One way this particular product helps a user is by having a clock timer where medication alerts can be set up which also has a snooze function. The other way this product alerts its users is by having a blinking light, which is especially helpful for people with hearing impairment. This product not only helps its users with maintaining their medication schedule, but it also is designed with accessibility in-mind. In the button control area, those buttons are larger than most digital electronic products on the market, which is also designed to extend its usability for a diverse population such as those with vision impairment or those with limited strength.

- Travel pill dispenser

![Travel pill dispenser](image)

Figure 5.2: Travel pill dispenser

Figure 5.2 displays a travel dispenser for a user's medication from Amazon. There are 3
of 3 5-stars reviews from customers in Amazon customers review system, and 9 of 9 people find reviews very helpful. From the feedback on Amazon, the author assumes that the travel pill dispenser is good and credible on the current market, which is appropriate for later analysis. Compared to the pill dispenser in the last section, this pill dispenser is more portable. This dispenser has 16 Ziploc-bags which are classified as daytime and nighttime use. What is more, each pill bag has an independent number on each label to help patients take their medication by order. However the problem with this dispenser lies in the fact that these labels do not provide any necessary information on when or how to take their medication.

5.2 Visual communication

Based on previous research in Chapter 2, senior citizens rely more and more on their knowledge, experience and long-term memory to recognize objects or interfaces. Based on such a theory, the first design guideline was brought about; that the interface developed in this portable pill dispenser design should be users are familiar or are experienced with, which will be helpful to expand the usability of new design to aging group. In this section, the figures below show some experiments on the conventional user interface which aim to prove the benefits of the conventional user interface. Figure 5.3 is twelve two-dimensional, outlined, nonsense figures (unfamiliar shapes); half of which featured a simple geometric shape (i.e., circle, oval, square, or triangle) when mentally manipulated.
Twelve cards were tested to two groups: one group is pre-cued, another group is non-pre-cued. In this experiment it was hypothesized that newly blinded individuals improve their proficiency in mental (unfamiliar shape) manipulation, and thus recognition of familiar shapes, significantly if visually pre-cued. Figure 5.4 shows the experiment results that pre-cued group is much higher than non pre-cued group, which proved the hypothesis stated above (Graven, 2005).
From the experiment result of Graven, the pre-cued or familiarized shapes are easily recognized and manipulated by old people with low vision. This result proves the fact that familiarized shapes and interfaces not only expand the usability to aging people, but also help all the people familiarize the interfaces of new design faster.

5.3 Universal design

There is a very brief definition of universal design: the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design (the principles of universal design, 1997). In this paper, the target group of the product in this paper is medication users who take several different kinds of medication and need a medication organizer. However, within this one group, there are huge diversities. For example, this group could be classified as people with chronic disease, aging people with vision impairment, and people with hearing impairment etc. All of the groups have the same demand and desire to have a way of reminding them to adhere to their medication regime and medication management. The author of this paper believes designers could provide some design solutions which could satisfy these needs of the different sub groups without adaptation.
or specialized design. There are two basic universal guidelines to follow:

- Provide the same means of use for all users: identical whenever possible; equivalent when not.
- Avoid segregating or stigmatizing any users.
- Simple and intuitive use
- Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

For the color selection of the interface, there are a lot of basic principles tested by other people’s work like below.

Designers often use a color wheel, a tool that arranges the colors of the spectrum by their properties. Primary colors include red, blue and yellow that cannot be created by mixing other colors. Secondary colors include orange, green and purple, which are created when mixing two primary colors. Complementary colors are opposite each other and provide contrast for readability. For example when choosing a primary color such as blue, its complementary color would be yellow. Adjacent colors to avoid would be orange and red or blue and green as they do not offer a high level of differentiation to the aging eye. An alternative choose colors from opposite side of the color wheel (Agelight, 2001).
Also, according to Wijk (2001), more frequent use of contrasting color would promote visual distinction in the environment, to support depth and spatial perception and to simplify object recognition. Also, basic colors (blue, red, green, yellow, black and white) for codes and cues in the environment are more appropriate than some mixed colors, which caused problems for a majority of the participants (turquoise, pink, orange and purple). They have problem of poor acuity with visual impairment, so visual details are not identifiable (Wijk, 2001).

5.4 Research on medication reminder technologies

Medication reminder technologies fall into three basic categories: (1) telephone-based medication reminders, (2) reminders integrated as part of home monitoring or safety devices and (3) electronic pill-dispensing systems. How do you know which of these product types is appropriate for the situation? Base your determination on the degree of intervention necessary to manage the medication management regimen (Orlov, 2010).

Telephone reminders are very useful for patients to adhere to medicine regime, but it only works for people who have their mobile phone on them every day. For aging people, they do not use cell phones as much as young people. From previous research, Jackson said not every aging person takes their mobile phone with them every day. Telephone reminders is effective but not perfect for aging people so since the goal of this paper is to provide a better portable pill dispenser solution, a home safety monitor
device will not discussed in this paper. An Electronic dispensing system has three ways of reminding people with its blinking light, sound alert, and vibration. Each way has its advantages and limitations. For example, a blinking light is effective for hearing-impaired people but not useful for those with vision impairment. Considering the advantages and disadvantages of each feature, the author would like to provide a new design which could satisfy all medication users.
CHAPTER 6: PROJECT DEVELOPMENT

6.1 Project parameters

Based on the previous research, interviews and design principles listed above, a new portable pill dispenser design would be developed and the parameter of the new design solution was set up below prior to the product's concept development.

( user-friendly, conventional, customizable number of days, parts with different functions which can be assembled selectively by users, instructions)

<table>
<thead>
<tr>
<th>PHYSICAL DIMENSION</th>
<th>USER INTERFACE</th>
<th>APPEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>small, easy carry</td>
<td>simple but intuitive</td>
<td>user friendly material</td>
</tr>
<tr>
<td>number of days customizable</td>
<td>use conventional interface</td>
<td>enough color and texture contrast</td>
</tr>
<tr>
<td>parts with different function which could be assembled</td>
<td>tactile cues for vision impairment</td>
<td>appropriate reminding method</td>
</tr>
<tr>
<td>selectively by users</td>
<td>visual cues for pill instructions</td>
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</table>

Table 1: Project parameters

6.2 Idea generation

After research and analysis, there are several dispensing methods that could solve the problems and design constraints discussed above. These dispensing methods are listed below:
Alternative I

Figure 6.1: Pill dispenser alternative I

The first posted concept is a multiple pill container that can hold all the medications for one day. There are several compartments in each container to indicate the order of pills by dividing them into different sub-containers. One example of its usage is to have the first sub-container hold all the pills taken before lunch and the second sub-container hold all the pills taken before dinner. What is more, all the individual medication containers could be assembled together so that the medication user could customize the number of containers they need. Another benefit to this dispensing method is that medication users could assemble some other function module to this dispenser like a reminder module and/or a pill-splitter module.

**Evaluation:** There are several advantages of this dispensing alternative in Figure 6.1 such as a medication user can customize the number of pill boxes and function modules.
Also the portability of this dispenser is better than design alternatives two and three listed below because the medication user only needs to carry one pill box for daily use. In addition, this design is not complicated which will effectively reduce the manufacturing cost. A drawback to this dispensing method is that it takes longer time to load the medications to the pill boxes due to the multiple sub-cases in each pill box.

Alternative II

![Diagram of Alternative II](image)

Figure 6.2: Pill dispenser alternative II

In this method, the device has a certain number of individual pill boxes attached together. Each individual pill box holds one kind of pills and the number of those pill boxes depends on the medication user’s regime (number of different kinds of pills). At the bottom of each pill box, there is a hopper to let the pills fall through to the ramp on the base. From there the medications could slide down the ramp and dispense to the medication user.
**Evaluation**: This dispensing alternative in Figure 6.2 has a single pill box for each type of pills, which is very convenient for filling medications to boxes. Also in this dispensing device, each box is larger and holds more pills for several days. Although this design has many strong points, it unfortunately has low portability which is a weakness since portability is a key feature of a portable pill dispenser.

Alternative III

![Pill dispenser alternative III](image)

Figure 6.3: Pill dispenser alternative III
This dispensing method consists of a pill dispenser, pill bottles and pill boxes dock. This pill dispenser contains several independent sub-pill boxes in order so to hold all the medications for one day for users. In addition, the cap of the pill bottles on the dock is specially designed to load pills to sub-pill boxes in the pill dispenser.

**Evaluation:**

In this design alternative, the highlight is that users cannot only easily load pills into each sub pill box from pill bottles but they can also slide the sub-pill boxes conveniently. The downside of this design alternative is the capacity of this pill dispenser. Users have to carry their pill bottles and load pills to this pill dispenser every day as it is only
intended to be used for one day.

6.3 Concept development

Based on the idea design alternatives discussed above, concept development was conducted which started with user interface design. From the user interface parameters in the last section, it is with conventional user interface with design elements the users are familiar with that would be applied to portable pill dispenser design of this paper.

Figure 6.5: Medication labels

The pictures above are some medication labels which are used to provide pill information to medication users. These labels usually include medication name, medication regime and dose which are key points to medication users.

On each pill container of each of the products in this paper, paper medication labels in Figure 6.5 could be applied to provide key information to medication users, while other subsidiary information will display on a LED screen.
After the analysis of the advantages and disadvantages, a new design solution based on design alternative 1 was developed, because alternative 1 stood out to be the best choice which could balance functionality and portability.
Figure 6.7 is a sketch model build thus far and it shows an improved version based on design alternative one; it is a customizable pill dispenser which consists of a pill-splitting function and a ring reminder. As identified in the image, the pill boxes can be assembled by inserting one into another. The head pill box on the left in Figure 6.7 is a function module which can cut pills in half, send signals to the ring reminder, and display information of the pills. The sketch model above shows how the new design solution works. Basically, there are many details such as user interface that needs to be developed and modified in further development.

Figure 6.8: Perspective view one

Based on previous research and sketch modeling, a visual rendering with the models with details was developed. In Figure 6.8, there is a new design solution of the pill dispenser and ring reminder. The pill dispenser contains several independent pill boxes
and the one special multi-functional box that contains the pill splitter which could help users with difficulty to cut pills into halves as stated in previous chapters. For the pill boxes, medication users can arrange the number of them as they need and assemble them together. Each pill box stores pills for one day's use. In the function box, it has a screen to display pill instructions and send signals to the ring component for reminders.

Figure 6.9: Setting up the pill dispenser

From previous research, a lot of medication users have difficulties of multi-task management. In the new design solution, the pharmacist could help medication user set up all the pill information and alerts in a computer program and upload them to function box via USB cable (Figure 6.9).
Figure 6.10: Pill-splitter

Users can press down at the rubber bar to cut pills into halves.

Figure 6.11: Pill reminder

Based on the Universal Design Principles discussed in previous chapters, the reminder in new design solution should be usable for all people. In Figure 6.11, The reminder
ring has three configurable ways of reminding people. A user can choose vibration, sound, or blinking light as their mode of being reminded. Additionally, the color of the ring will match the color on the compartment and indicate which pills in which compartment will need to be taken. In each compartment, it holds different kinds of pills taken by the same time. For example, the first compartment may hold all the pills are suppose to be taken in the morning, the second compartment may need to be taken at noon.

Figure 6.12: Assembling pill boxes

Usually, the pill dispensers currently on the market have at least seven pill boxes, and those pill boxes cannot be assembled or customized by users. Compared to the products currently on the market, users will only need to add one pill box to the function box for
daily use. In the pill box, there are several individual compartments for medicines to be taken at different times.

Figure 6.13: Medication labels

Base on previous research, medication users often have messed up their medicines because of not enough information of medicines. In Figure 6.13, users can stick on key information of the medicine to the cover of pill boxes.

6.4 Setting up dimensions

After the idea was developed, some experiments were conducted to study conventional pill dispensers' physical dimensions. Because there are a lot of pill dispensers on the
market that have been in use by medication users for several years, the physical dimensions and volume of the individual compartments have been tested by medication users for a long time. In this thesis, the author has assumed that the physical dimensions and volume of the pill dispensers on the market could be taken as reference to set up the dimension of the idea developed in the last chapter.

Figure 6.14: Dimensions of pill dispensers currently at the market

In the picture above, three common types of pill dispensers on the market with different structures were measured to gain information on their physical dimensions. The sizes of pill dispensers are listed below.

a. Round shape dispenser, individual compartment size 2.5” x 2” x 1.5”
   It can hold 30 aspirin tablets.

b. Lined-up dispenser, individual compartment size 1.5” x 1.5” x 2”
   It can hold 20 aspirin pills.

c. Round stackable pill dispenser, individual compartment size 2” x 2” x 1.5”
   It can hold 24 aspirin pills.
From the previous information presented in the introduction and background chapter, only two out of five seniors take more than five prescribed medications. Considering medication users are not all seniors, most medication users take less than five prescribed medications. Additionally from medication research gathered from the pharmacy, most medicines state that the user should take up to two tablets at once and take them two or three times daily. The author of this paper assumed the new solution of pill dispenser should have a capacity of 30 tablets (six tablets times five kinds of medicines equals 30 tablets). Therefore based on previous research, the dimensions of the new design solution were set up below shown in Figure 6.16.
The size of new design solution is 2”(W) x 3”(D) x 1.5”(H), and the capacity is over 30 tablets for one day use.

6.5 Pinch strength research for pill-splitting function

As stated in previous chapter, the multi-functional box could be used as a pill-splitter or pill-crusher. Medication users only need to pinch on rubber bar, and pills will be cut into halves by the blade at the middle of multi-functional box. Normally, most people have no difficulty to use the pill splitters which work in the same method listed above. In senior citizens group, most of them keep losing their hand strength slow. Picture below is an experiment of hand strength research.

Figure 6.17: B&L pinch gauge, key pinch is thumb pad to lateral aspect of middle phalanx of index finger.

(Grip and Pinch Strength: Normative Data for Adults, 1985)

The B&L pinch gauge, used to measure tip, key, and palmar pinch, was held by the
examiner at the distal end to prevent dropping. Scores were read on the needle side of
the red readout marker. The calibration of both instruments was tested periodically
during the study.

<p>| Table 4: Average Performance Of All Subjects and Key Pinch (pounds) |
|---|---|---|---|---|---|---|---|---|---|</p>
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<th>Age</th>
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<th>SD</th>
<th>SE</th>
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</table>

From the table above, the fact is obvious that people start to lose their hand strength
gradually after age fifty-five. Considering the universal design discussed in previous
chapter, the usability of new design should satisfy at least 95% of people. So the pinch
strength to cut pills in new design should be less than 25.2 pounds (woman 75+
maximum pinch strength 12.6Xdouble hand=25.2 pounds), the data above could be
used as a reference for further manufacture (Grip and Pinch Strength: Normative Data
for Adults, 1985).
CHAPTER 7: EVALUATION

After the product development stage, a simple product evaluation was conducted with the prototype model made by a 3D printer to confirm that the new design features were well applied to the product, and benefit the target user group.

7.1 Self-evaluation using simulation

The medication user simulating method in the previous research stage was applied again in this product evaluation stage. In this product evaluation stage, the author of this paper used the prototype model to adhere to the prescribed medication regime. In order to find how much convenience the new design brings to medication users, a comparison usability test was conducted between the new design and the portable pill dispenser on the market. The most obvious improvement experienced from the new design's model is that it could generally provide all the functions which medication users needed to be assisted in. For instance, the new design could dispense pills, give reminders for the pills, split pills, and provide pill instructions. Another marked benefit of the new design was the high contrast between the instruction background and text which was very clear and legible for author of this paper to read. In addition, the physical dimension of the new design was very small and convenient to carry. Through the whole test, the only thing that made the author feel a little bit bothered was in pasting the medication instruction labels to the cover of individual pill boxes repeatedly. However, while this step could be omitted, the information on the labels may be necessary to medication
users who suffered an impaired memory in the process of managing their pills.

7.2 Evaluation from target user group

After self evaluation, the new design was brought to a target user group for product evaluation. Katie, who took part in the interviews in the previous research stage, participated again to help the author get some feedback of new product’s usability. The comment given by Katie was about the ring reminder. She mentioned she loved the ring reminder design, because the ring is not only more convenient to carry than reminding products on the market for example a vibrating watch. Not only did she love the ring design but also the multiple reminding methods such as blinking light, sound alerts, and vibrations. She said she would never miss taking her medicines with this ring reminder design, but she was also concerned about whether the ring was waterproof or not. She thought the usability of the ring reminder would be greatly improved if the material of ring was waterproof, because she would not have to take it off while washing her hands. Also Katie stated that she was able to easily recognize which compartment of the pill box corresponded to the specific doses to take by the flashing light indicator on the side. She also noted that the tactile cues to indicate the day of week on the individual pill boxes were very easy to distinguish from each other just by touching them. Moreover, Katie pointed out that the high contrast of background and text on the labels with the medication instructions were effective, however she could still expect the size of text to be larger due to her vision impairment.
7.3 Future changes in medical industry

New developments in the pharmaceutical industry happen every day and more medications are becoming available in patches. Many people find that they prefer the drug delivery method of patches and find them convenient. Since most medication patches allow the user to bathe and swim, they are not disruptive to daily life.

Compared to conventional tablets, medication patches have several advantages and disadvantages. For instance, medication patches could release the pain to take a bunch of medicines tablets orally, medication patches could provide a quicker deliver system and last longer than normal pills medication patches, and medication patches save users’ time to manage those pills. But there are also some issues, not all people can absorb medications effectively. Also, some people sweat more than other people, it may influence absorption of medication.

Medications in patch form are still a new market, and there are some issues. Patch placement education is needed. As well, not all people absorb medication from patches equally. Things like skin heat, and also skin tolerance can affect absorption. In tests on the medications in patch form for attentional disorder, about 13% of patients became tolerant of the medication, blocking the skin from absorbing it.
In conclusion, this thesis illustrated the portable pill dispenser design process, starting from gaining a deep understanding of the target users and also an empathic experience with the pill dispenser and reminder. In addition, some interviews with medication users and pharmacists were conducted to find the shortcomings of the usability of the products currently on the market and to help the author set up the product parameters. Then a portable pill dispenser and reminder with a universal user interface were developed to provide solutions in response to the difficulty in usability found in the previous research.

The value of this thesis can be summarized as three points below:

A. While there are many products on the market, they are either too expensive with complex computer-aided user interfaces or too simple without accommodating important functions like a pill splitter. In this thesis, the device provides a simple, multifunctional, customizable and portable pill dispenser for people who need to carry a pill dispenser to manage their pills while they are in transit.

B. Based on universal design discipline, the user interface developed in this thesis combined visual cues and tactile cues for a medication user with vision impairment,
which expand the scope of the product's usability and accessibility to the greatest tent.

C. The advantage of this thesis could be found in the fact that it emphasized a good interaction between a medication user and their pill dispenser, as it is barely considered and applied to pill dispenser products on the current market. The decreased consideration for interaction between products and its users is due to the widespread increase of computer-aided technology in the medical industry. Some people complain about the complexity and unintuitive design of computer-aided interfaces that have several buttons and seemingly endless pages of instructions. So the thesis' designed the device provides an innovative solution which aims to give users a positive experience and it also aims to create an easier and intuitive user experience.
CHAPTER 9: REFERENCE


