Usability of a medication adherence application on a smartphone

by

Yves Vimegnon

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CERTIFICATE OF APPROVAL

This is to certify that the Master's capstone of

Yves Vimegnon

has been approved.

Holly Jimison, Ph.D., Associate Professor, Graduate Capstone Advisor

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Abstract

Background/Aims: Many senior adult patients often face the use of multiple medications with challenges in adhering to the agreed upon regimens. This study focused on addressing health literacy, an underlying medication non-adherence factor. A smartphone application to deliver medication regimen instructions in an easy-to-understand format was developed and tested for its usability by seniors.

Methods: Niaspan 500 mg, a drug with a relatively complex regimen, was presented to seniors with minimal text information, images, and verbal instructions from a Palm Pre 2® smartphone. A Discount Usability Testing of the application was performed with a Think Aloud experiment including a Task Performance test. In addition, the participants were asked to assess the User Interfaces with a short Usability Heuristics Checklist and answer a User Personal Feedback Questionnaire.

Results: Nine people, 65-86 years old, including four females and five males participated in the study. They all found the application efficient and satisfactory. About 78% of them found it engaging. It was easy to learn, error tolerant, and memorable according to 89% of the participants. On the incidental drug information recall, they had an aggregate test performance score of 71% as a group. On the information retrieval task, they achieved an aggregate score of 96%. Only one of the participants had a prior experience using smartphone.

Conclusion: A senior-friendly smartphone application for medication adherence can be used and useful to seniors.

Chapter 1

1. Introduction and Background

1.1. Medication non-adherence as a major public health problem

Adherence to a medication regimen is the extent to which a person's behavior in terms of taking medication corresponds with agreed recommendations from a health care provider.[1] Non-adherence is a public health problem of staggering magnitude, rightly described as an invisible epidemic.[2,3] Its rate is estimated in chronic disease patients at 50% in the US and other developed countries,[4,5] although the prevalence rate varies with conditions. Non-adherence is a worldwide problem associated with the global aging and many chronic conditions that sometimes require complex medication regimens. The death postponement effect of medical advances prolongs longevity, albeit with an increased burden of chronic diseases. The use of multiple medications becomes necessary in the management of these chronic diseases.

Over 77% of seniors between 65 and 75 years of age suffer from one or more chronic conditions.[6] It has been estimated that individual seniors aged 65 to 69 take 14 medications per year, while those aged 80 to 84 take 18 medications per year.[7] Seniors therefore represent the segment of the US population with the largest consumption of medications associated with an exorbitant price tag in healthcare expenditures.

Medication non-adherence can be specifically defined as the number of doses not taken or taken incorrectly that jeopardizes the patient's therapeutic outcome.[8] Approximately 10% of hospital admissions,[9] and 125,000 deaths per year by cardiovascular diseases[10] were attributed to non-adherence to prescribed medication regimens. Non-adherence related morbidity and mortality cost is high in the US. It has been estimated at $300 billion in annual healthcare costs.[11] Based on reports from the Institute for Healthcare Informatics, there was a 3.5% increase drug sales from $308.6 billion in 2010 to $319.9 billion in 2011,[12] although non-adherence has not been improving in the past five decades. This situation is a clear call for action.

1.2. Role of health literacy in non-adherence to medication regimens

Non-adherence is a multi-factorial problem. These factors include, but are not limited, to functional health literacy, suboptimal or absence of medication and disease state education, side effects, medication regimen complexity, polypharmacy, cost of medication, and cognitive impairment. Functional Health Literacy (FHL), among all these factors, is the focus of this research. It is defined as the ability to read, comprehend and act upon health instructions,[13] and plays a substantial role in non-adherence. Kripalani et al., reported that Medication Management Capacity (MMC) is significantly associated with literacy.[14] Seniors are more likely to visit the emergency department and be re-admitted during the first six months after discharge, when they have to deal with more than five new drugs. Approximately 55% of the population has basic or below basic level of literacy[15] as shown in Figure 1.1.

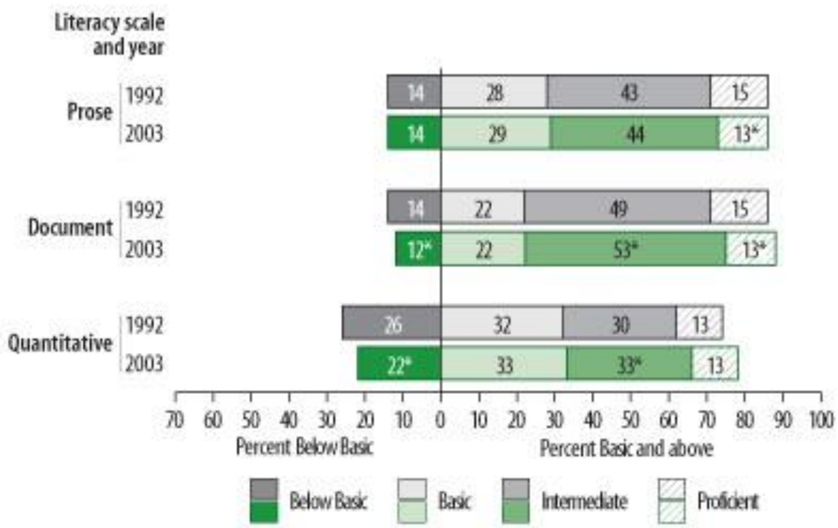

Figure 1.1: Percentage of adults in each prose, document and quantitative literacy Level –This shows a comparison of the results from 1992 and 2003

* Significantly different from 1992.

NOTE: Detail may not sum to totals because of rounding. Adults are defined as people 16 years of age and older living in households or prisons. Adults who could not be interviewed due to language spoken or cognitive or mental disabilities (3 percent in 2003 and 4 percent in 1992) are excluded from this figure

Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, 1992 National Adult Literacy Survey and 2003 National Assessment of Adult Literacy (NAAL)

However, health literacy is not necessarily related to years of education or general reading ability. In terms of health literacy, the statistics show that over 75 million adults combined had basic and below basic health literacy. And, among those with below basic literacy level, 29% are aged 65 or more,[15] as shown in Figure 1.2, and 1.3.

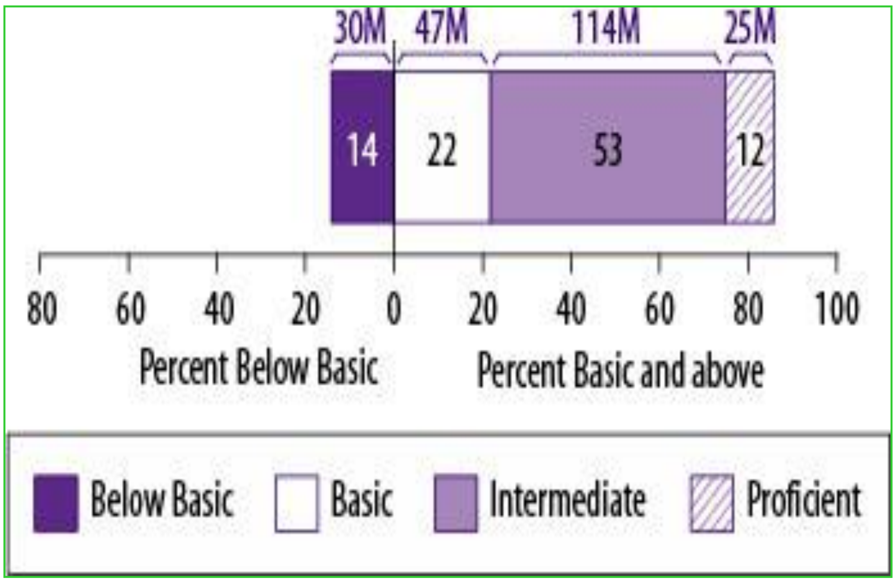

Figure 1.2: Percentage of adults in each health literacy level, by age. These are the results of the 2003 survey.

Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, 1992 National Adult Literacy Survey and 2003 NAAL

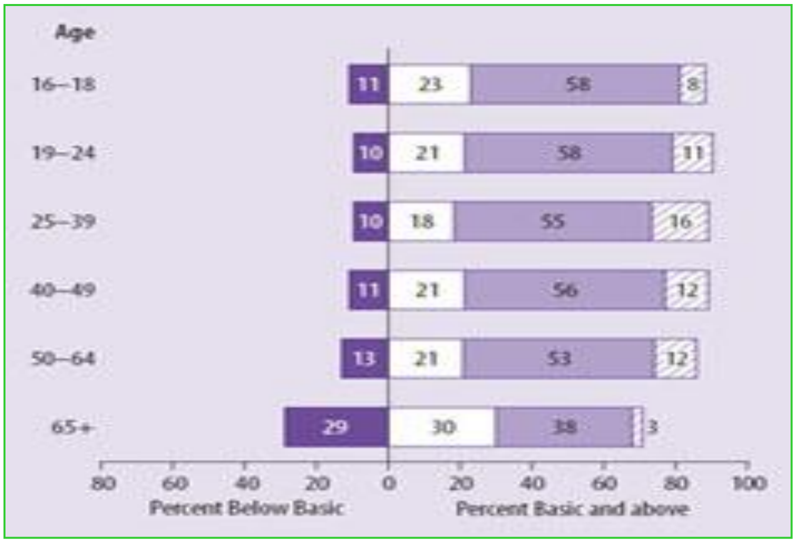

Figure1.3: Total Population: Number & Percentage of Adults in Each Health Literacy Level: These are the results of the 2003 survey.

Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, 1992 National Adult Literacy Survey and 2003 NAAL

The National Assessment of Adult Literacy (NAAL) defined three types of literacy. [15] Prose Literacy, Document Literacy, and Quantitative Literacy, as shown in Figure 1.4.

Figure 1.4: The importance of health literacy in health consumers' activities.

Source: U.S. Department of Education, Institute for Education Sciences, National Center for Education Statistics, National Assessment of Adult Literacy

These three types are germane to non-adherence, as they relate to the skills needed to read, understand, and sometimes perform simple computations required in taking some medications. Many authors reported the need to render drug information in an easy-to-understand format for patients. [16-18] Daniel Morrow et al. found that patient-centered drug information rendered at low grade reading level were preferred by patients to standard instructions on packet inserts.[19] A 2006 review of the literature on medication adherence found that the combination of textual, oral, and pictorial communication has a value in enhancing adherence to medication regimens.[20]

1.3. The growth of medication assistive devices available to health consumers

A large number of medication assistive devices have emerged. These electronic media include, but not limited to, automatic pill dispensers, electronic pill boxes, pillbox caps, medication reminder systems via Web-based services, diverse smartphone applications and text messaging systems. The use of mobile devices for medications in healthcare started with Portable Digital Assistants, and has been growing since the early 2000s. In the past five years, this trend has increased exponentially around the world with the explosion of feature phones, smartphones and tablet computers. Today, mobile health applications are being used in clinical settings for direct provision of care, real-time monitoring of patient physiologic states, public health and research even in remote areas where electricity infrastructures are non-existent. The resulting field called mHealth, a sub-segment of eHealth, is growing fast due to the high penetration of mobile telephony in low and middle-income economies. The World Bank reported that by the end of 2011, more than 80% of people around the world had a mobile subscription.[21] In the US, a Pew Research Center survey found that 11% of feature phone users and 19% of smartphone users now have at least one health application on their mobile devices.[22] The report was based on a nationwide survey of 3,014 adults living in the United States. There are some indications that senior adult patients will embrace mobile health applications. The general penetration of smartphones is still low in the US compared to other parts of the world. The national average is 46% with 13% of people aged 65 and older.[23] Although smartphone ownership by seniors is relatively modest, it is possible that may prefer smartphones to other devices for use as medication assistive device. In her capstone work or a Master in Biomedical Informatics, Jennifer Abramson performed a Discount Usability Testing (DUT) of various medication assistive devices. She reported that her study participants, mostly seniors, showed preferences for cell phones.[24] It is important to note however, that it is unclear whether many of the currently available health applications have a conceptual design targeting specific non-adherence factors. Forgetfulness addressed with reminder alarms seems to be the most prevalent non-adherence factor being targeted.

1.4. Project Objectives

1.4.1. Research Question

This exploration of the usability of a smartphone application developed for the delivery of medication regimen instructions was done with the following specific question:

"Can people aged 65 and older easily use and be satisfied with a smartphone giving them instructions on using a medication?"

1.4.2. Specific Aims

The achievement of the project's objectives required two specific aims as follows:

> **Aim 1**: To develop the medication adherence application on a smartphone
>
> **Aim 2**: To perform a discount usability testing of the developed application

Unlike many of the existing medication adherence applications, we specifically plan to add to the combination of textual, oral, and pictorial communication to the reminder alarm of the study application. The rationale is to address two non-adherence factors: forgetfulness and functional health literacy.

Chapter 2

2. Methods

This work included a close look at the Functional Health Literacy paradigm and the elements of this paradigm that can effectively help in addressing medication non-adherence. The development of the material to be tested was followed by the actual testing of the prototype application.

2.1. The medication adherence application

2.1.1. The conceptual framework of the application

The medication adherence application was designed with the conceptual framework of the Dual Code Theory (DCT), and strategies such as Patient-Centered Instructions (PCI) that stand to help seniors and people challenged with Functional Health Literacy (FHL). According to the DCT, the human brain codes incoming information through two separate channels, visual and auditory.[25-27] This process of knowledge representation and storage becomes useful when the need for relevant action arises. The presentations of drug information with visual and auditory stimuli appear as a means to increase knowledge and understanding of prescribed medication regimen. The image encoding may have a substantial effect on recall. Consistent with the previously mentioned literacy statistics, the drug information rendering from MedP targeted below basic literacy level. In addition to this strategy against the FHL factor, reminder alarms for dosing time were also used for the forgetfulness factor. Based on the DCT and the literature findings in favor of visual and auditory aids, the capabilities of a smartphone seemed interesting to explore.

Similarly the UI design fairly matched the considerations of the Patient-Centered Instruction (PCI) design and schema of Morrow et al.[28,29] These authors found that senior adult patients tend to organize medication information into three categories ordered as follows: general information about the medication (purpose), how to take (dose and schedule), and outcomes (emergency information). This is a logical format that the MedP application design was also conceived with. The purpose and dosing time are the first information that users must have access to when it is time to take a medication. The emergency information principle was also given due consideration through the creation of "Contact" and "Side Effects" buttons. Finally, simplification and reduction of the amount of textual information drove the overall UI design, as it was also given priority.

2.1.2. The selected drug regimen

The lipid lowering agent, Niaspan 500 mg, was selected for the relative complexity of its regimen. It requires Aspirin intake prior to its dosing time. Therefore, two reminders are needed with a 30 minute interval before Niaspan should be taken. There are four choices of food to consider taking with Niaspan. These include taking the medication with a low-fat snack such as: (1) milk, (2) crackers, (3) yoghurt, or (4) banana. Regular exercise, most days of the week is an additional recommendation. For the purpose of making the regimen easy-to-understand, and addressing health literacy challenges, the recommendations of the Niaspan regimen were grouped under the label "DOs" represented with green color icons and buttons. Text instructions, verbal instructions and Illustrative images were used to convey the required actions. These were behaviors or actions that the user must take. Similarly, there were five actions to avoid with Niaspan. These were grouped under the label "DON'Ts," represented with red color icons and buttons. Text instructions, verbal instructions and Illustrative images indicated that Niaspan should not be crushed, and should not be taken (1) on empty stomach, (2) with spicy foods, (3) with hot beverages, and (4) with alcohol, should be avoided.

2.2.3 The software development

a) The coding process

The medication adherence application called MedP was developed over a total period of six months, from August 2011 to January 2012, on a part time basis. The work consisted of an iterative development process that involved the researcher and a PhD student in the Department of Medical Informatics and Clinical Epidemiology. The application was a WebOS2 application created in the Palm's browser-based, web-hosted development environment called Ares that included the following utilities:

- A drag-and-drop visual interface builder
- A code editing environment
- Visual Javascript debugger
- Log Viewer Utility
- Framework enhancements to support easier layout and event handling
- Single-click deployment/launch on device or emulator
- Drag-and-drop file upload, file/project download
- Version Control Integration (SVN/Mercurial)

The MedP development tasks included, but not limited to:

- Development of a script of the medication regimen instruction
- Recording of the verbal instructions of the Niaspan regimen from corresponding scripts
- Development of a library of pharmaceutical pictograms
- Coding with Javascript and HTML
- Building a small database to store users' interactions with the application.

The researcher focused on the UIs design while the developer worked mostly on the Javascript codes. A pharmacist, faculty at the OSU/OHSU College of Pharmacy helped with the verbal instructions of the Niaspan regimen. Great attention was given to the verbal instructions, short texts, and illustrative images, and icons. The MedP application included a total of 26 UIs before the DUT. The development followed an iterative development methodology, whereby the researcher directly worked on every detail of the UI of the MedP application from the first version to the last (version 0.4), which was tested in the study.

c) The hardware

The final version of the prototype MedP application to be tested during the project was installed on a Palm Pre 2®,[30] which has the following basic specifications:

- Dimension: 100.7 x 59.6 x 16.9 mm (3.96 x 2.35 x 0.67 in);
- Display: 3.10 inches, 320 x 480 pixels
- Touchscreen: Capacitive, Multi-Touch.

The Palm Pre 2® hardware for this project was a generous donation from Hewlett Packard before HP decided to discontinue its line of Palm products.

2.2.1. Test Interface

Consistent with the DCT of Allan Paivio and the PCI considerations from Morrow et al., the UIs were designed to be engaging with minimal text instructions at low-grade reading level, with pictures and automated voice over the interfaces. The touch of most images on the screen activates corresponding vocal instructions. Figures 2.1 through 2.4 are examples of the 26 UIs were tested by the study participants.

Figure 2.1: MedP App's "Quick Info" Screen provides in one screen the essential of what a user needs to know while taking Niaspan

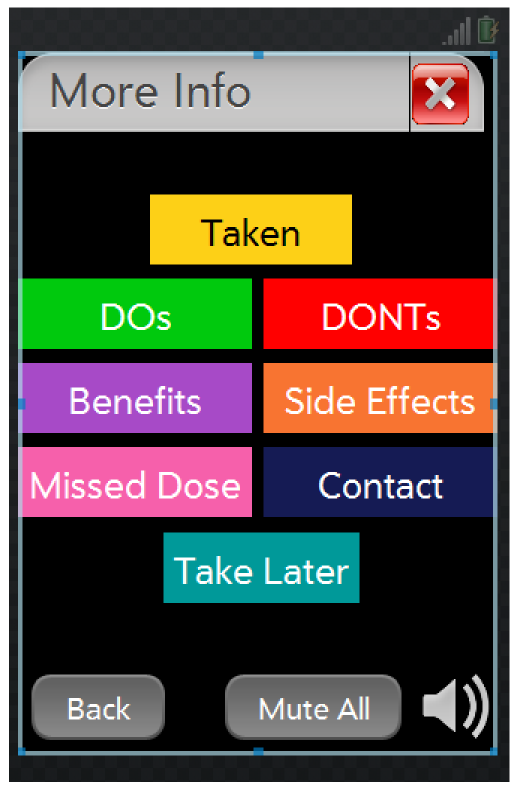

Figure 2.2: MedP App's More Info Screen is a portal to detailed information about the drug including prescriber's contact number and how to handle a missed dose.

A user can mute or allow all the MedP screens to speak automatically. By default, only the "Quick Info" screen speaks automatically after a reminder alarm.

Figure 2-3: MedP App's DON'T screen showing 5 types of actions to avoid when taking Niaspan

Figure 2-4: MedP App's DON'T screen showing four types of recommendations while taking Niaspan

Figure 2.1 designated with the title bar "Quick Info," is the portal to the Niaspan drug regimen. It provides the user with the essential of the medication regimen in a single interface. From the "Quick Info" interface the user can view the following:

- Purpose of the medication,
- Double-sided picture of the medication,
- Illustrative icons for DOs and DONTs leading to detailed information on other screens,
- Buttons for the user to indicate that the medication is already taken, or will be taken later,
- A button labeled “MedList” to see personal medication schedules and a record of responses to alarms in a table, and
- A button to navigate to the more information window.

The “Quick Info” interface appears on the Palm Pre2 after a reminder alarm at 9 pm, which is the time Niaspan is scheduled to be taken. The regimen requires the user to take 325 mg of Aspirin 30 minutes before Niaspan. For this reason, MedP gives first a reminder alarm at 8:30 pm. While the “Quick Info” interface can speak automatically, the other interfaces speak only on demand. Upon these alarms, the user automatically hears: “It is time to take Aspirin,” followed by “It is time to take Niaspan” after acknowledgement of the alarm. When the user does not respond to an alarm, MedP stops after the third round of sounding it. Each round is separated by a 15 minute-pause.

2.2.2. Participants

Several visitors of the OHSU Outpatient Pharmacy were unsuccessfully approached until the first participant accepted to volunteer 48 hours after signing an informed consent. This first participant suggested other acquaintances in a Northeast Portland community. From this participant, who was the only smartphone user, the recruitment started growing as snowball sampling in the same community where many of the participants live or have social interactions. Participants were however purposefully selected to include people of different native languages, races, and educational backgrounds. They signed informed consents to participate, consistent with the regulatory provisions of the OHSU IRB and responsible conduct of research.

2.2.3. The study conduct

(a) Time and Place

The MedP application on the Palm Pre 2® smartphones was tested by each of the recruited nine participants in single instances that lasted from 45 minutes to an hour. The entire study took three weeks, from the day the first participant was approached to the day of the last participant's actual DUT. A packet consisting of a manila envelope including a consent form, and a business card was left at the front porch of the homes of each of the potential participants. These potential participants were approached after 48 hours to schedule their participation times. The DUTs were performed in the comfort of their homes.

(b) Testing procedure and pills identification set up

To begin the test, the researcher reiterated to each participant the purpose of the study, reviewed the consent form with them, and showed them the study phone with a pill box full of children vitamins of diverse colors. The vitamin pill box did not contain Niaspan. But participants were not informed. They were only told that they would have to recognize later from the pill box, the pill that they would see from the phone. The rationale was to see whether participants could recognize and differentiate Niaspan from the vitamins based on the pill's picture display from the phone. One side of the Niaspan medication is plain. The other side has an imprint of a 500 with an Abbott logo; and the pill is an orange color capsule-shape tablet. With these characteristics, Niaspan is very distinct from the vitamins, unless some attributes of the pictures and the UI create some confusion. After this step, participants were shown the basic operation of the phone, and asked to explore them on the phone for one to two minutes. Due to their apparent hesitancy, participants were encouraged that smartphones and the application were easy to use. Finally, participants were asked to do a Think Aloud Experiment, which included two rounds of interactions with the phone. The starting time of each round of interaction was signaled by the MedP application, which is reset each time to produce the sound within two minutes. After the Think Aloud Experiment, participants were asked to provide comments based on a Usability Heuristics Checklist, and their personal opinions. The checklist included the original five quality components of Jakob Nielsen's "Usability Goals,"[31] namely:

- Learnability
- Efficiency
- Memorability
- Errors (as in low error rate or Tolerance)
- Satisfaction

The "Engagement" attribute of a UI was added to extend the Usability Heuristics Checklist to six components.

2.2.4. The think aloud experiment

The experiment was guided by the script in Table 2.1 below. While the participants were interacting with the MedP application, the researcher observed them closely, and took note of their actions and comments.

Table 2.1: Scenario of the Think Aloud Experiment.

Now let me tell you a use scenario of the application. This is what I would like to test with you: Imagine you get a new prescription for which the information is on this phone. Then, you are given the phone to help you take the medication every day. The phone will show you the picture of the medication, its name, when to take it, what to do and what to avoid. If you want to know any information on the prescription, just touch the button that is designed for it. You can mute the phone or make it speak.
The Experiment
Now, I am going to observe you while you use the phone. Please, speak so I know what you are thinking. I would like to know whether the application is easy or difficult to use. So, please think aloud as you interact with the phone. **You may start when you hear the ringtone. This pill box is supposed to contain the medication.**

2.2.5. Tasks to perform

The first round of participants' interactions with the MedP application was uninterrupted and uncontrolled. Participants were not given any direction as to what to look for or tasks to perform. They were given five minutes to freely explore the application. Since the objective of the MedP application was to increase users' knowledge and understanding of their medication regimens, the effectiveness of this functionality was checked right after their first round of interaction with the phone. Participants were asked five questions as shown in Table 2.2. After they provided their answers, they were asked to start the second round of interaction which was then controlled and directed. They were asked to perform the steps required to access or show from the phone the same information that they were asked to recall earlier. The researcher proceeded with one question at the time in the order shown in Table 2.2 below.

Table 2.2: Task performance questions

Tasks	**Interface Goals**
1. Which one was the medication? *(Participant was presented with many pills in a pill box)*	Pill identification
2. What it is for?	Show and tell the indication of the medication
3. When are you supposed to take the medication?	Alarm and tell that it is time to take the medication
4. Did you get some suggestions for properly taking it?	Show and tell the DOs & DON'Ts of the regimen
5. Do you remember any of the listed side effects?	Show and tell side effects

2.2.6 Analysis

Although the DCT and PCI are relevant to the conceptual framework of this project, its analysis was not polarized by its psychological constructs and materialization during the testing. Consistent with discount usability procedures and its primary objective,[31] the recorded data were focused and reviewed to extract usability issues. Problems that participants encountered and verbalized were the crux of the observation and analysis as opposed to participants' cognitive processes. Therefore, the discussion was rather succinct from a neuropsychological standpoint.

Chapter 3

3. Results

3.1. Participant demographics

Ten participants aged 65-90 years old were enrolled including five females and five males as shown in Table 3.1. The oldest of them that were approached, was a 90-year-old lady. Except for this dropout case, the other nine seniors completed the study as volunteer participants. They all live independently. Half were college graduates, and the other half completed high school.

Table 3-1: Demographics and smartphone use experiences of the participants

ID	Age	Race	Sex	Education	Native language	Smartphone user
1	72	Caucasian	Male	High School	English	Yes
2	72	Caucasian	Male	Pharmacist	English	No
3	76	Asian	Male	High School	Vietnamese	No
4	82	Caucasian	Female	High School	English	No
5	86	Caucasian	Female	College	English	No
6	70	Caucasian	Female	College	English	No
7	74	Caucasian	Male	High School	English	No
8	83	Black	Female	College	Liberian	No
9	65	Black	Male	College	Swahili	No
10*	90	Caucasian	Female	High School	English	No

* This participant decided to withdraw from the study

3.1.1 The dropout case

The oldest lady was enrolled before changing her mind about participating, when the researcher came her house on the day of the study. She reluctantly looked at the device's interface, touched a couple of buttons, shook her head and returned the phone in less than a minute with an apparent feeling of nervousness and discomfort. She said that she does not need this type of aid in her life, she only takes a pain medication when needed. She also said that she has an old feature phone, which her daughter did not succeed in having her accept overnight.

3.2. The think aloud experiment and usability problems found

All the participants seemed fascinated by the novelty in their hands. They expressed, however, their difficulties and opinions about the application. Their comments are summarized in the Table 3.2. Although they encountered some usability challenges, they didn't face outright technical barriers to using the application. All participants dealt with a specific challenge in the use of the touchscreen functionality of the phone. It was most remarkable with the "Quick Info" screen. Yet, the individual who personally owns and uses a smartphone did better than all the others. He did not touch the wrong buttons as many times as the rest of the participants did on the "Quick Info" screen.

Table 3.2: Comments and observations from the think aloud experiment

Comments and Observations	Number of feedback	Proportion
Participants wanted to be able to see Med List anytime they want.	2	22%
Participants wanted to "Close" a page, but not end up in Search Dialogue Box screen.	4	44%
Avoid going in circle when participants use the phone's own return function. Stop vocal instructions started from the screen where the return function was used.	3	33%
Participants needed guidance for what to do after the alarm sounded.	6	67%
Participants wanted to hear vocal instructions from pictures on DOs and DON'Ts screens.	5	56%
Curious and playful participants wanted to touch everything.	3	33%
Participants wanted to avoid touching the "Take Later "button when they tried to reach the "More Info" button. Participant wanted to be more accurate or more successful in touching the desired buttons. (Phones had to be reset.)	9	100%
Participant wanted to see all Side Effects on one long list to scroll down, instead of two separate screens to navigate to.	1	11%
Participant wanted to have the ability to manually set dosing time.	1	11%
Participants needed to be able to quickly see and identify the Niaspan picture on the "Quick Info" screen.	5	56%
Participant wanted to be able to manually do medication reconciliation from the phone	1	11%
Participant wanted a feedback on missed doses records.	1	11%

On this particular screen, participants would instead touch the “Take Later “button when they intended to touch the “More Info” button. Although for the rest of the interfaces the touchscreen functions were operated as intended, the buttons seemed to be pressed harder than they should. They are sometimes pressed repeatedly. Three of the participants did not encounter other challenges apart from touchscreen challenges. Six of the participants experienced other types of challenges, although the usability test proceeded overall smoothly.

3.3. Task Completion

This phase of the DUT included five tasks pertaining to two areas of knowledge or understanding of the Niaspan regimen, namely:

1. Identification of the Niaspan pill among six different pills in a pill box.
2. Telling or finding the other Niaspan drug regimen information.

The findings of participants’ performance in terms of knowledge or recall of what they saw or heard from the MedP application are summarized in Table 3.3 below. Participants freely explored the application, then were asked to perform all the five tasks in Table 3.3. Although the first interface of the application, the “Quick Info” screen, showed the medication’s name and purpose, not all participants noticed that automatically from their first encounter or free exploration of the application. As a result they did not all know or remember what they just saw or heard from the application about the dosing time or DOs and DON'Ts of the Niaspan regimen.

Table 3.3: Results of pill identification and recall of drug information, right after the first round of interaction with MedP

Statistics	**Task #1** Correct Medication Identification	**Task #2** Recall of Medication Purpose	**Task # 3** Recall of Timing	**Task #4** Recall of DO/DON'T	**Task#5** Recall of Side Effect
Correct Response	6	8	5	7	6
N	9	9	9	9	9
Proportion	67%	89%	56%	78%	67%

Participants demonstrated as shown in Table 3.4 that the navigation of the application was easy for them. They were asked to perform each of the five tasks below. Almost all of the participants were able to access from the phone, even the information that they did not know or could not directly recall after their first round of interaction with the application.

Table 3.4: Results of pill identification and recall of drug information during the Controlled Task Completion Test of the second round of interaction with MedP

Statistics	**Task #1** Correct Medication Identification	**Task #2** Recall of Medication Purpose	**Task # 3** Recall of Timing	**Task #4** Recall of DO/DON'T	**Task#5** Recall of Side Effect
Correct Response	9	8	8	9	9
N	9	9	9	9	9
roportion	100%	89%	89%	100%	100%

Lastly, the results of participants' responses with the Usability Heuristics Checklist are summarized in the following Table 3-5.

Table 3-5 Participants' responses to the UIs with the Usability Heuristics Checklist

Usability Heuristics Checklist	Percentage of positive responses to the UIs
Learnability	89%
Efficiency	100%
Memorability	89%
Tolerance	89%
Satisfaction	89%
Engagement	100%

3.3. Unexpected findings with the application

Two of the participants were surprised that the application provided them with important information that they never knew, or their physicians have never discussed with them.

3.3.1 Lack of information on proper use and avoidance of a prescribed drug's common side-effect

For one participant, Niaspan was coincidentally one of the medications that she has been taking. This participant was surprised that she was supposed to take Aspirin 325 mg, 30 minutes before taking Niaspan. She did not know that this measure was intended to help reduce, or prevent the flushing side effects of the drug. No one has ever told her that. No one has ever told her most of the DOs/DON'Ts that the MedP application was presenting to her.

3.3.2 Discovery of a possible medication side effect

The other participants learned from the application that muscle pain is a severe side effect to discuss with one's physicians, whenever one is taking a lipid lowering drugs. This participant started expressing a suspicion about his own drug, which was of the class of drugs known as Statins. He assumed that although he was not specifically taking Niaspan, the unexplained muscle cramps and pains that he was experiencing might be due to his Statin. He discussed that with his daughter and decided to bring his feeling to the attention of his physician. He appeared as having learned something new from the application and seemed visibly grateful for getting that information.

Chapter 4

4. Discussion

4.1. Participants

The final number of participants was nine, although five participants could have been enough according to Nielsen et al.[32] This expansion of the sample size was purposefully done to diversify the study sample. It allowed for inclusion of male, female, White, Black, and Asian participants to assess possible variation in the results based on race and/or gender. However, after five of the nine participants did the Think Aloud Experiment, no new information was being added. It was clear that additional participants would not be more informative or useful, consistent with Nielsen's recommendation from a cost/benefit perspective.

4.2. Recall questions and participants' performance

4.2.1. Rationale for the recall questions

Jakob Nielsen's usability engineering premises considered the fact that people perform memory recognition better than they can perform memory recall.[31] For this reason, minimizing users' memory load is the basis of the recognition principle of UI design and usability evaluation. Recall was instead considered and used in this work, not in relation to the usability of the UIs. Since the application engaged visual and auditory senses, the recall questions were intended to check whether participants captured what the application displayed or said to them. This was a test of the DCT and the PCI, the two conceptual frameworks of the application. This rationale helped assess, to some extent, the utility of the underpinning theories of the MedP application.

4.2.2. Participants' cognitive performance

Short term memory can be a problem in the participants' age segment. Therefore, the questions were asked as soon as possible. In the first round of the recall questions, 89% of the participants were correct with the purpose of the medication. Conversely, only 56% of them could recall the dosing time of the medication. On the five facts of the medication regimen that were assessed, the rating of their group performance can be represented as follows: Purpose > DOs/DON'Ts >Side Effects and Pill Identification> Timing. Table 4.1 shows the MedP outputs that produced these result.

No image was provided for the dosing time, and the regimen alarm which was 9 pm could not be used for the daytime testing. As a result, the worst participants' performance was observed with the dosing time question.

Many authors reported the superiority effect of pictures or images on understanding, learning, and free recall.[33-35]

Table 4.1 MedP outputs and their results

Medication Regimen Facts	**Correct Performance**	**Format of the MedP output associated with the Medication Regimen Facts**
Purpose	89%	Text=+ Voice=++ Image= 0
DOs/DON'Ts	78%	Text=+ Voice=++ Image=++
Side Effects	67%	Text=+ Voice=+ Image= 0
Pills Identification	67%	Text=0 Voice=0 Image=+
Dosing Time	56%	Text=+ Voice=+ Image= 0

+ represents the number of times the output format was used

The image artifact of a 9 pm alarm clock could have helped participants in their responses to the medication dosing time question. Although the purpose of the medication did not have an illustrative image, most participants gave the correct answer for the purpose. This was the participants' highest performance scenario. In the Dual Coding Experiments, verbal codes did not prove to have higher impact on recall than images as was the case in our testing. This specific result was incongruent with Paivio et al.'s work. It can be attributed to the fact that participants heard the mention of cholesterol more than one time, in addition to the corresponding texts presented on multiple interfaces.

The DOs/DON'Ts facts were provided with text, images, and, voice. With the three MedP outputs, it was logical to expect the highest number of correct response from this combination of outputs. This is where Paivio's DCT is most expected to be proven true, since it was reported that image and verbal memory codes are independent and additive in their effect on recall.[34] Participants' performance on the related questions were however lower than in the case of the medication purpose question. One can argue that there was an information overload from the DOs/DON'Ts screens. There were indeed ten images total for the DOs/DONTs questions.

Finally, the pill identification question did not yield the highest answer. The Niaspan pill's picture might not have had its expected effect, because the "Quick Info" interface has other information and engaging icons that can easily divert participants' attention. They did not spend much time on that first screen as they were very interested in navigating to the other screens to satisfy their curiosity. But the Niaspan image cannot be missed from a repeated viewing of that "Quick Info" interface with an intentional search for the Niaspan image. This explains why all subjects easily recognized Niaspan in the second round of questions.

The second round of questions was different. Participants' performance was overall excellent with 89 to 100% correct responses to the recall questions. It was not an incidental recall question round. Some of the participants had answered the questions that they missed even before performing the tasks required to access the information from the phone. The above table content and analysis do not take into account the performance of the single participant who had a Niaspan prescription from her physician. Only participants who were naïve to Niaspan were considered. In summary, the eight participants, naïve to Niaspan, had an aggregate test performance score of 71% as a group on the incidental drug information recall questions. On the information retrieval task, they achieved an aggregate score of 96% as a group.

4.2.3. Usability vs. Utility of the MedP interfaces

From a usability perspective, participants performed well the requested tasks, as noted for the second round of questions. They were able to navigate the UIs, understand its state, know where they were within the application, and give correct answers. They did not have to use their recall memories to access the information that they were asked. Their recognition of the actions and objects of the UIs helped them succeed the tasks. We can conclude that the application was usable. Usability is sine qua none to utility. However, due to the cognitive processes involved, it is important to also consider here the MedP application's utility or impact on the knowledge of the participants. It is obvious that a real and fair assessment of knowledge and understanding of the Niaspan medication regimen would need participants to first spend a little be more time with the application than the DUT afforded. For this reason, it seems appropriate to say that the DCT and the PCI strategies helped the subjects to some extent. Their performance on the incidental recall questions was definitely worse when an image was not associated with the information provided. From this perspective, the application can be as useful when visual and auditory stimuli are combined and appropriately provided. Working memory and executive function are reported as useful in medication adherence.[36] This would be remarkable in the adherence to the Niaspan medication regimen, where consumers have to take Aspirin and Niaspan minutes apart, and also plan for the recommendations grouped under the DOs and DON'T's categories. MedP images and verbal reinforcements can be useful for these purposes. After a repeated use of the application, users may be able, with a dual coding of the information, to recall the scenarios and hopefully not even have to depend on the MedP application for some of the instructions. They might only have to acknowledge their medication intake with the "Taken" button. According to Paivio el al "Recall tests following manipulations of voice and image inputs have proven to consistently yield much higher recall for images than for voice inputs under all conditions except when subjects imaged to words."[34] Testing the MedP application in more structured conditions with the premise of imagery-evoking verbal cues[37] may be needed to elucidate or dismiss some of the observed incongruence with the results of the experiments of Paivio's et al.

4.3. Technical Challenges

There was no outright technical barrier to using the application. The usability test proceeded smoothly with all nine participants. This is attributable to the overall ease of use of the smartphone itself as hardware, and to the intuitive and minimalist, yet engaging design of the MedP application. The observed technical challenges relate to some of the smartphone features and/or MedP interface designs. The design was task-oriented allowing the participants to quickly access the information they were asked during the Task Performance Test. As John Carroll underlined, brevity is key in minimalism and task-oriented activities.[38] Most of the texts were brief. Most of the information were reached with two touches of the screens.

4.3.1. Touchscreen Challenges

Every participant unintendedly touched a wrong button. This was the major technical issue during the testing. The close proximity of certain buttons to each other was accountable for this error especially on the "Quick Info" screen. The frequency of this error can be explained by the close proximity of the buttons and their small sizes. The small size of the smartphone's screen did not allow for designing larger buttons or at least 1/8 inch space between them on some interfaces. All the needed buttons on a screen must fit the allocated space, in order to meet the role of the "Quick Info" screen serving as a "portal" to the other screens. Tremors in participants can also be obvious explanations for unintended touch errors. However, they were not observed in any of the participants. Although spacing the buttons appeared as a straightforward and simple design solution, the challenge in reaching precisely the right button or operating the phone with the touchscreen might still remain. Participants did not seem to have acquired or known the necessary light touch, yet effective gesture that seamlessly produces a touchscreen response. By design, a touchscreen does not require a hard touch for an effective response. Palm Pre 2's touchscreen uses capacitance sensing technology. Unlike a resistive sensing technology, capacitance only needs a distortion of the screen's electrostatic field by the human finger electrostatics to function.[39] Participants needed not to press as hard and as long as it may be required for a resistive touchscreen. Most of them tended to press too hard, or keep too long the pulp of their fingers on the screen. The issues would not have probably been remarkable and occurred repeatedly with most of the participants, if they were long time touchscreen users or if they were given an initial orientation on the use of the type of touchscreen they were facing. Most of them might probably be used to some resistive touchscreens.

4.3.2. Fast and easy access to the MedList

As designed, MedP users could not access the MedList from within any of its open screens, except from the "Quick Info" screen. Placing a MedList icon outside of the application just as the MedP application's icon itself is a workable solution. This will allow users to easily access their medication list anytime right from the desktop of their phone, without having to first open the MedP application. To ensure users' privacy, the enforcement of password rules for login into the phone should be required as it currently is for most smartphones.

4.3.3. Proper control over the "Close" buttons of the UIs

User control over an application is an important usability principle. It is a freedom that a user should be afforded in the navigation of the screen of the application as Arnold Lund suggested in his expert rating of usability maxims.[40] To end up on a "Search Dialogue Box" page while attempting to close a MedP screen is certainly not a desirable operation. It is as if the system is controlling the user, or forcing him/her to take unwanted actions. This is not good for the user experience (UX). This usability issue was due to the slow responsiveness of the MedP application when its upper right corner "Close" buttons were touched repeatedly. As the system is slowly processing a first touch to close a screen, a second touch of the close button leads user to the unwanted Palm Pre 2® Search Dialogue Box screen. Optimization of this non-functional requirement part of the MedP code was warranted. It also appeared that this close buttons on all screen, can afford the user some control with two options. One option may be to confirm the intent to exit the application. The other may be to revert to the "Quick Info" screen, since this screen serves as a home page or portal for the Niaspan drug regimen.

4.3.4. Proper control over the use of the return function of the Palm Pre 2® smartphone

The lack of synchronization between the return function of WebOS2 and MedP application explains the uninterrupted playing of the medication vocal instructions after the user has navigated away from the corresponding screen. Recommending users to only use the Back buttons of the application, and avoid using Palm Pre 2's return function is not the best solution. Users are likely to make the same mistake and experience subsequent frustration. It seems better to find a way to allow the return function to control both the MedP UIs and associated functions at the same time, like voice files within the MedP code. In order to avoid users' frustration from endless rotation through the UIs when the "Back" button reaches the "Quick Info" screen, users can be afforded two navigation options. One option should confirm the intent to exit the application. The other should allow continuation of the backward navigation action. This solution is consistent with the above UI discussion regarding user control. A complete disconnect of the return function of the Palm Pre 2® from the MedP application can make the application independent, and eliminate the issues. It depends on what is allowable within WebOS2 design and architecture. However, it seems like most, if not all, smartphones' operating systems are designed to control installed applications from their return functions.

4.3.5. Participants' hesitancy after MedP reminder alarms

Some of the participants' hesitancy seemed to relate to lack of confidence and fear to fail the task performance test. This seemed justified. Having never used a smartphone and facing a test with this unknown device can certainly cause nervousness. The apparent quick dissipation of this feeling and the great performance of the participants showed that (1) the reiteration of what they are expected to do (2) the simplicity of the operation of the smartphone, and (3) a few words of encouragement were helpful. The time given to the participants to explore the Palm Pre 2® smartphone for the first time and try its basic operations should have been extended to three or five minutes. This could have made them more comfortable with the phone before the actual DUT. The development of a user's guide video tutorial for the MedP application appeared as a good idea, although the application is simple and the performance of the usability testers confirmed it. It may be helpful for the beta testing of the application as an alternative for a user's manual. This video tutorial premise may however still not work for people who are curious, impatient, and eager to begin right-away, if they feel it as impeding their natural impulses to solve problems by themselves.

4.3.6. Hearing vocal instructions from pictures on DOs and DON'Ts screens

Enhancing UX is an important part of the design of a mobile health application. Engaging UIs and features can make users curious as seen with the participants in this study. Hearing verbal instructions from the touch of some images made some of them even curious with various parts of the UI. Since the pills images were touched, it seems important to implement this feature to help confirm the identification of the displayed pills with the sound of their names. The usability testers expected the DOs and DON'Ts icons to play the instructions, which they did. These expected features are easily implementable, and should be done in the final version of the application.

4.3.7. Curious and playful users wanted to touch everything

It seems like the unprecedented excitement with digital technology that is captivating the younger generations is worth exploring. Therefore, having the opportunity to test a smartphone, or touching it for the first time can be an opportunity to check out that excitement. The five participants who touched the pills pictures demonstrated a curiosity that the design of the application did not satisfy. The three among them who touched other parts of the screens including MedList display, and traffic lights to symbolize DOs and DON'Ts appeared as the most curious and playful participants. This impression was also reinforced as they touched the "Take Later" button, although they could read it, and they knew that the DUT was for a short period of time. As pointed out earlier, the close proximity of the buttons on the "Quick Info" screen was a factor in to consider in the unintended touches of the button. But it is possible that some of the participants simply wanted to see the phone's behavior when they touch that "Take Later" button. In these specific situations, participants did not also verbalize their thoughts. Lastly, it seem appropriate to also think that they might not know that by touching the "Take Later" button, they were snoozing the alarm or telling the system to remain inactive until the time for the next dose of the medication comes. As mentioned earlier, the "Take Later" button touch should be designed to ask users to confirm their intents.

4.3.8. Viewing all side effects from a single scrollable interface

Although only one participant made this suggestion, it sounded good and has the value of reducing the number of buttons to touch in the process. With this suggested alternative design, users may however loose the intended short text concept, and clear distinction or separation of severe and mild side effects. A simple workable solution is to put the title of the side effects (severe side effects vs. mild side effects) and on a same page, and make these titled to be expandable. The information under each title is displayed on the same page as the title is exploded.

4.3.9. User wanted to have the ability to manually set the medication dosing time

This desired feature was beyond the scope of the project. However, the system can be designed to allow for a simple way of setting the dosing time. This option may be placed in Medication list outside the application. Although this is not a usability issue, in order to meet the ultimate goal of an adherence application, the set medication schedule should be a shared decision between the prescriber and the consumer.

Users should always have control over their medication regimens, but automating the medication regimen prescription system is more practical and maybe safer. From the e-prescribing system of the healthcare provider to the consumer smartphone application through the pharmacy, all information should be easy to monitor and automated to avoid discrepancies.

4.3.10. Users needed to be able to quickly see and identify the Niaspan picture on the "Quick Info" screen

This desired feature was also beyond the scope of the project. The application can be developed to have an animated pointer to the pills picture or an animated pill's picture.

4.3.11. Performing personal medication reconciliation

This was another desired feature beyond the scope of the project. The system may be designed to provide a control as an option to delete medication or modify the medication regimen. This function may not be necessary when the MedP application is operating with an automated data feed system involving e-prescribing. However, full control over this type of personal assistive device and medication regimen should always be given to the user.

4.3.12. Having feedback on missed dose records

This was the observed last desired feature beyond the scope of the project. The application can be designed to place this feedback in the MedList module outside the main application, or accessible from the "Quick Info" screen.

4.4. Cognitive Barriers

4.4.1. The decline to participate in the DUT

The anxiety and discomfort of the 90-year old lady was visible through her facial expression and her quick return of the phone to the investigator. She pointed out that she only uses a couple of medications anyway. It took her long to accept the feature phone that her daughter gave to her to use. She did not think of the application as a necessary device at her age. She had never used a smartphone, and was no interested in it. This new technology called "smartphone" might be the last thing on her mind. It was probably by simple courtesy that she accepted to even listen to the idea of a study with a smartphone application. Her reaction to drop out of the day of the study appeared as a defense mechanism against the anxiety and the notion of testing a new technology that she did not care for. She was curious enough to accept to take the smartphone in her hand and touch a few of its buttons. Her refusal to proceed further may be simply due to a fear of embarrassment. This embarrassment may be based on a lack of confidence in her ability to operate the phone, or to perform tasks that may be required of her. To use the age factor and others as the reasons for not wanting to test the application can be seen as rationalization, and rationalization is a mechanism of defense against the anxiety that she was unable to hide well.[41] It is however logical to say that having a good memory and only one pain medication to take as needed, does not require a medication reminder system. For this reason, a reminder is utterly unnecessary for her. The fact that she has a high school level of education made it clear that she simply did not want to deal with any feelings from the testing of the application. Large population of non-literate people are using mobile phones around the world.[21,42] But, testing an application on the phone itself can apparently be perceived differently.

4.4.2. The observed general hesitancy pattern

While the internet is clearly perceived by some as irrelevant to them,[43] new technologies like smartphones and their applications can be also seen as burdensome, or gadgets most appropriate for the younger generations. This type of rationalization could also serve as a disavowal defense[41] against anxiety when it comes to usability testing of the latest smartphone applications. But unlike the oldest lady, the rest of the seniors voluntarily completed the DUT. The oldest lady's reaction was not however peculiar, because a noticeable level of hesitancy was also observed with most of them who completed the testing. This common attitude can be attributed to the compounded nervousness of having to manipulate a "delicate or great technology" and the apprehension of the cognitive process that the testing itself might involve. Yu and Dickinson et al. reported similar observations in their work with seniors faced with the use of computer technology.[44,45] It takes the ability or willingness to transcend the rationalization and the nervousness about the test, to participate in the DUT and complete it. Curiosity about the actual new technology was most likely a driving force in the decision to volunteer for the study. This probably helped some of the participants to quickly overcome their initial hesitant attitude. As of April 2012, 53% of seniors aged 65 and older use the internet or email.[46] The digital divide is slowly closing, but the statistics still show that a great number of seniors are not too excited to embrace the emerging new technologies.

4.4.1. The choice of visual aids

The application's UIs were purposefully designed with images, voice, and text to render the medication regimen easy-to-understand at all level of health literacy. It is however possible that some of these visual aids were not meaningful to all users. Many factors come into play in individual cognitive processes. While some icons might not be familiar icons, others could even be perceived as inappropriate from some cultural or educational perspective.[47] We could have gathered this type of information, if the study was designed accordingly. The MedP UI design with a combination of voice, text, and images conveying the same message fairly makes it qualify as a Universal Design. Giving users the option to choose the type of aids (visual and/or auditory) that meet their personal preferences is a desirable solution.

This solution goes beyond usability testing. It is feasible in the context of a website environment where widely accepted icons can be pre-determined through a voting mechanism. For consistency and medication safety reasons, selected icons, pharmaceutical pictograms, or other visual aids by a target should be retained and further popularized.

4.5. Methodological Issues

Consistent with Ericsson and Simon's key recommendations[48] for Think Aloud Experiments, interactions with the participants were minimized. But the MedP application needed a reset each time the "Take Later" button was touched. This happened with all subjects. The button temporarily closes the application as is the case with an alarm snooze button. It was an indication that the system should have been designed to ask users to confirm their intent, whenever they touch the "Take Later." This would give users more control, and might be more useful both in the usability test and beta version of the application.

In six instances, the strict observation of the minimal interaction principle could not be maintained. Reiterating the need to touch buttons on the screen of the phone was like a necessary prod to get some participants started. They turned to the researcher wondering what they should do after the alarm, even though they were instructed in the introduction to the test. It seemed as if they just wanted to hear the phrase “okay go ahead!” This wouldn’t have probably happened if the initial demonstration of the smartphone application was not limited to hardware’s own basic operations. The decision to proceed in this manner was to avoid showing how the application works prior to the actual testing. Participants’ own discovery of the test interfaces is essential. The fewness of the interfaces and steps to reaching them, in addition to the simplicity of the application warranted that decision. In retrospect, it is clear that participants could have been given a chance to explore a similar application with a drug less complex and different from Niaspan. This rationale is in line with authors, such as Yu and Dickinson, who based on the “hesitant use pattern” that they found with their participants suggested that a “certain amount of exploratory behavior is necessary for the participant to perform the tasks required during the DUT.” This exploration is particularly important for the elderly volunteers because of their anxiety, even possible thoughts and fear of making mistakes that might damage the testing device. Finally, the usability problem relating to the slow response of the “Close” buttons and use of the WebOS2 return function were the other instances that led to additional interactions with some participants. These again were user control issues. As first time smartphone users, they were confused and perplexed. They needed to hear that, they should get out of the screen if they wanted to do something different. WebOS graciously allows users to tap a bottom center line to shrink a screen before pushing upward to disappear.

4.6. Additional Design Considerations

The usability test revealed design improvement areas, some of which fall in the category of future features because they were beyond the scope of the project. Following are suggestions in addition to those already discussed above within each technical challenge section.

4.5.1. Video Tutorial

Since 67% of the participants did not know what to do after the application sounded an alarm, verbal instructions in the form of a video-tutorial definitely seems important for seniors. The application may be installed on a smartphone with this video tutorial. For the DUT purposes, the design of the video tutorial may also include the suggested few system requirements specification:

- System shall have a voice recording to tell users what to do after hearing the alarm.
- The recording should also tell users from that screen how to control the volume of the application.
- System should provide a clear user guide for using touchscreen
- System shall provide this guidance on the MedList, if it is placed outside the main MedP application.
- System shall provide a ‘Repeat Option,’ or tell users from the guidance instructions to tap twice the speaker icon anytime they want to repeat an instruction.

4.5.2. Icons Selection

The choice of icons is very important in the design of the user interface. Since some pharmaceutical pictograms or icons can be found inappropriate or offensive, a process whereby various icons will be presented to the target audience with the option to vote for their favorite images or preferences may be very useful. A web platform can be used to make this type of determination. The votes can instantly yield universally adopted icons.

5. Limitations

There was no plan to investigate users' opinions of the effectiveness of the selected icons in the UI design. This assessment could have elucidated participants' engagement or satisfaction with icons such as those used to illustrate "taking a medication on an empty stomach." The importance of these usability heuristics may warrant the inclusion of questions that assess images that are intended to enhance understanding of the medication regimen and the user experience. The medication regimen instructions did not strictly follow the PCI schemas of Daniel Morrow. For example, the side effects were not accessible from the Quick Info page. Preference was given to the MedList to allow users to have a list of the other medications that they are taking including their adherence record, within the main MedP application.

Conclusion

Mobile health applications can be adopted and successfully used by people over 65 years of age and older. Individual reluctance and feelings of incompetency with associated negative emotions can be transcended. To achieve this objective, it is important to afford senior users an assisted exploratory period with the technology. They discover through this exploration period that the application designed for them is indeed easy-to-use. This strategy is facilitated user interfaces created with the priority to enhance user experience with engaging and useful features. Minimalist and universal design principles cannot be overlooked. Multimedia artifacts such as voice, pictures, and minimal amount of texts can facilitate incidental recall of the information being provided while they also address functional health literacy challenges.

The slight touch gesture required to operate a smartphone can have a learning curve for some senior users. To avoid subsequent frustrations, it seems important for all mobile health applications to be designed with large screens hardware, and large buttons. This design consideration can help minimize the dissatisfaction and abandonment of the application, especially by seniors with visual and tactile challenges. Fascination and personal curiosity that the elderly users show may not last long. To help sustain the expected information seeking behavior, mobile health applications such as MedP should strive to highlight important information easy to omit in busy clinical or pharmacy practice settings. These types of information add value to the utility of the application, apart from its easy recall benefits from vivid pictorial information. It was interesting to realize that this small project's unexpected findings or discoveries by two participants led them to rethink their medication regimens or talk to their physicians. Whether the emergence of MedP-type applications will fill the gaps in the provision of important drug information will adversely impact patient-provider relation is unknown. It is however certain that consumers can obtain from devices designed like MedP, just-in time, clear, and important information, that can be helpful and essential to discuss with their physicians. A demonstrated utility of this type can foster sustained use of a mobile health application.

Finally, it is important to note that the sustained use of a mobile health application should be driven by the constructs of the principles of health behaviors theories, or underlying factors of the condition being addressed. Challenges like health literacy, well known as a barrier to medication adherence, warrants targeted solution. Smartphone applications being developed in the mHealth ecosystem should have a conceptual framework approaching non-adherence as multi-factorial non- problem. In addition to health literacy, other non-adherence factors and behavioral theory constructs are areas of future work to ensure tailored interventions or optimal medication adherence plans. Similarly, the determination or produce of a large inventory of pharmaceutical pictograms and icons universally acceptable and adaptable to various medication regimens is needed. Finally, more exploration is also needed in the area of dual coding theory to determine its optimal utility to working visual memory and incidental recall of verbal cues.

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Glossary

- **Adherence:** The extent to which a person's behavior in terms of taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider.
- **Discount Usability Testing** is a cost-effective method of usability evaluation based on three techniques: scenarios, simplified think-aloud, and heuristic evaluation. These often require fewer resources and time than formal usability testing.
- **Document literacy**: The knowledge and skills required to perform a document task. Examples of document tasks: searching, understanding, and using non-continuous texts such as food, pill bottle labels, transportation schedules, etc. (NCES,2003)
- **Heuristic** refers to experience-based techniques for problem solving, learning, and discovery. Where the exhaustive search is impractical
- **Medication non-adherence**: The number of doses not taken or taken incorrectly that jeopardizes the patient's therapeutic outcome.
- **Prose literacy**: The knowledge and skills required to perform a prose task. Examples of prose tasks: searching, understanding, and using continuous texts such as instructional materials, news stories etc. (NCES,2003)
- **Think-aloud:** A commonly used method in usability engineering. Originating from cognitive psychology, Nielsen (1993) popularized its use among usability engineers.
- **Quantitative literacy:** The knowledge and skills required to perform quantitative tasks, such as balancing a checkbook, figuring out a tip, completing an order form or determining the amount (NCES,2003).
- **Usability:** The quality of a tool that permits completion of a task with ease, efficiency, and satisfaction.
- **User experience** (UX) is the way a person feels about using a product, system or service. User experience highlights the experiential, affective, meaningful and valuable aspects of human-computer interaction.