

Pilltender

Automated Pill Dispenser for Seniors with Memory Loss

TEAM MEMBERS

Paper prototyping, testing, analytics, and mockup creation were each done in part by four team members: **Shadman Abedin**, **Allison Chou**, **Celina Hipolito**, and **Will Wang**.

PROBLEM AND SOLUTION

A common problem faced by aging citizens is **memory loss**. Regularly forgetting things can impair a person's ability to complete daily tasks done efficiently, if at all. Memory loss includes a wide spectrum of symptoms, so for this project our group focused on assisting senior citizens with mild memory loss, who live in their personal home and are still mostly mobile and able to communicate.

We explored a wide range of ideas, including a general monitoring system implemented as a tile floor within the user's home, but we found these solutions to be too shallow-reaching and difficult to install. We turned to our research to find a narrower focus and discovered that a common problem faced by seniors with memory loss is remembering to take medication.

Our solution to address this problem consists of an **automated pill dispenser**. Family members and/or caretakers are able to insert medicine bottles into the machine ("Pilltender"), which then alerts the senior citizen and dispenses pills into a specialized cup at the appropriate times.

INITIAL PAPER PROTOTYPE

Our initial paper prototype was a 3D model with two components: (1) a pill dispensing machine (“Pilltender”) with an interactive UI screen that dispensed water and pills, and (2) a specialized mug that held both water and pills dispensed from the machine.



Our design was meant to be used by two groups of people: seniors with memory loss, and their family members or caretakers. **Task 1 involved scanning and verifying a new medicine for the machine.** This task was meant to be completed by caretakers, and is a bit more involved than the next. For instance as part of our task, we had one field display the incorrect information which would require the user to edit it. This task highlighted two critical features of the design early on, which was the scanner which read the label of a pill bottle and the pill pods (orange cylinders on top of the box) which held medicines after being scanned. Although these features were modified based on testing feedback, they remained an important aspect of the design throughout our process.

Task 2 involves being reminded to take medicine then taking medicine, and is meant to be completed by the senior. This task was more about passively receiving guidance, as the main screens seen by the user in this task are large instructions with pictures and an accompanying voice instruction. A critical feature highlighted in this task is the special mug included with the machine. At this stage in the design, the machine cannot operate without the mug so it is essential that interactions involving the mug are done correctly, such as replacing it in the machine when finished.

TESTING PROCESS

Our testing process included **two heuristic evaluations** and **three usability tests**.

For the heuristic evaluations, we had two rounds of evaluations:

1. Members of Hermes, tested in class with Celina as the computer, Will as note taker and Allison and Shadman as facilitators
2. Members of amisu, tested in the MHCID studio with Will as the computer and note taker and Celina as the facilitator.

These participants went through our two tasks and evaluated our paper prototype's usability against Nielsen's heuristic principles. Their observations were written down on cards and highlighted usability issues in our initial design. After rating these issues for severity and fixability, we were able to address the key issues before performing usability tests.

For the usability tests, we were unable to meet up so the three tests were done independently. Although this limited our capacity to evolve our testing process, we were still able to get some helpful feedback from these tests. Our ideal participants would be real caretakers and seniors with memory loss. However, given the limited amount of time, we opted for testing with our peers while informing them of the user they are representing. We chose participants that do not work or study in the technology industry so that they are less likely to judge the technology, but the usability. All of our tests involved the same tasks outlined in the heuristic evaluation section: scanning and loading a new medicine, and taking medicine.

Our first test was conducted by Will, with a 26-year-old male college student. The test was conducted in the participant's home, since the design context for the product is mainly home use.

Our second test was conducted by Celina, with a 20-year-old female college student majoring in biochemistry. Although the participant is familiar with common consumer technology such as a cell phone and laptop, she is not very familiar with UX/UI concepts. In the past, she has lived with a grandparent and although they did not suffer from memory loss, she is familiar with the daily routines and pain points experienced by seniors. The test was conducted at the participant's apartment.

Our third test was conducted by Allison, with a 20-year-old male college student majoring in philosophy. The test was conducted at the participant's apartment.

To ensure consistency, all tests were performed using the same script, which can be found in Appendix II. For the most part, each participant had a streamlined experience with using the paper prototype. There were a few minor issues, which are identified and resolved in the following section.

TESTING RESULTS

The feedback from our heuristic evaluations and usability tests informed changes made to our final design. Since our design has to do with the health and wellness of seniors, clarity of status and instructions is essential. Feedback from our heuristic evaluations showed us areas for improvement in making interactions more clear.

- **Consistency and standards (severity 2):** One group brought up the fact the “Edit” button on the home screen might be confusing because the user does not know what exactly they are editing. The “Edit” button originally encompassed Settings of the machine, such as mapping “morning” or “evening” to different times of the day, and editing medicine information. To address this, we split the “Edit” button into three separate features: “Add new medicine”, “Edit medicine”, and “Settings”.
- **Visibility of system status (severity 2):** There is currently no progress indicator when a new medicine bottle is being scanned in by the system. One group brought up that scanning medicine might take several seconds. According to Nielsen, some indicator should be added for response times longer than 1.0 seconds. We added a progress indicator to the UI screen in order to give the user more peace of mind and insight into the scanning process.
- **Flexibility of use (severity 2):** Some people may prefer speaking commands rather than trying to figure out a graphical interface. The option to input through voice rather than pressing buttons, rather than simply a non-interactive voice narration, was implemented for those users.
- **Visibility of system status (severity 3):** Although our research found that many seniors stay on one floor within their own homes, there is a chance that they still may not hear the notification. Notifications to take the medicine should be more persistent.

Some of the feedback with the tests overlapped with each other, along with from the heuristic evaluations. It is noted when this happens, because these overlapping issues indicate a common problem likely to be encountered by multiple users.

From our first test, we mainly learned about some accessibility issues with our design.

- **Efficiency of use (severity 2):** Some of the buttons and font sizes were too small for seniors to read. This was fixed by making them larger.
- **User control and freedom (severity 4):** Despite the machine telling them to return the cup, the senior may still forget to place the cup back or want to remove the cup to wash it. Without the correct cup, the user cannot take the pills next cycle. Notifications to place cup back should be more persistent, and an option to use a different cup should be included.
- **Flexibility of use (severity 4):** Some seniors may want to have the pills taken to them, rather than having to find the machine to use it. While this is a great point to consider,

addressing it directly would be a level 1 difficulty and addressing it would require completely redesigning our system.

- **Flexibility of use (severity 2):** This participant also suggested adding VUI in additions to simple voice instructions to make the system more accessible for users who prefer to speak.
- **Visibility of system status (severity 3):** The participant also suggested making the notifications more persistent to address the issue of the senior being far away.

From our second test, some high level issues and a maintenance feature were highlighted.

- **Flexibility of use (severity 4):** This participant also mentioned how some seniors may want to have the pills taken to them, rather than having to find the machine to use it. As mentioned before, this issue has a level 1 difficulty and would require completely redesigning our system.
- **Visibility of system status (severity 3):** This participant mentioned another issue brought up before, about how the senior may not hear the notification. This indicates that it is very important for notifications to take medicine should to be very prominent.
- **Help and documentation (severity 3):** The user may not know when to refill the water tank when it is empty or close to being empty. To fix this issue, we added a message that alerts the user when the water tank is getting low and needs to be refilled.

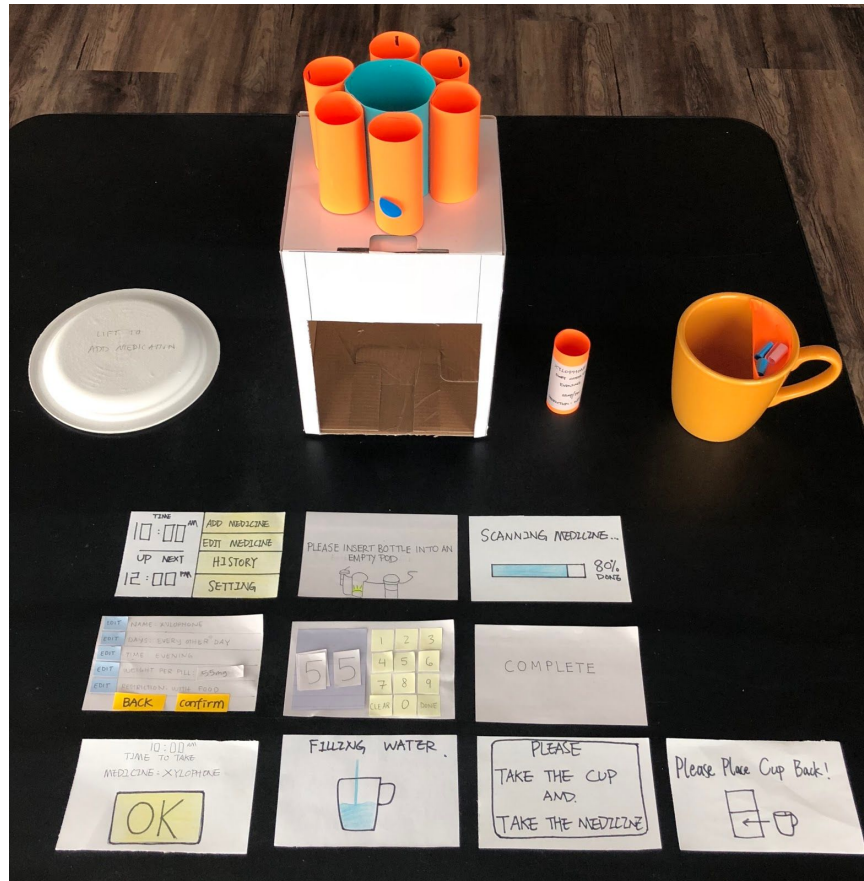
From our third usability test, the home screen was made to be more clear and help avoid error.

- **Match between system and the real world (severity 2):** Buttons on the home screen were still confusing and could be condensed. There was no intuitive way to refill medication, so we changed the buttons to “add new med(icine)”, “refill med(icine)”, “history”, and “settings”. All the information previously in “edit medicine” are now under “settings”.
- **Error prevention (severity 3):** The senior might accidentally hit buttons on the home screen, become confused, and unknowingly mess up the system. To fix this, we added a general home screen that displays the time very prominently. This is what the senior will usually see when looking at the system. There is now a small arrow on the right side of the screen that is meant for the caretaker to edit information on the system. The caretaker can toggle between the two screens via the arrow button on the right side of the screen. This will hopefully minimize the amount of accidental errors from the senior.

From in class critique, we got feedback on our initial digital mockup. Most of our peers thought that our tasks were simple and straightforward. The tasks that required more interaction, such as editing incorrectly scanned information, could be made cleaner by lining up the text fields and hiding the other fields while editing one. Another big point lined up with feedback from usability tests, which was making a way to make sure the user can get around an error caused by the cup not being in the slot. Considering a snooze button on the alarm that tells the user to replace the cup might give the user more freedom to do things like wash the cup.

FINAL PAPER PROTOTYPE

Our final paper prototype was once again a 3D model with two components: (1) a pill dispensing machine (“Pilltender”) with an interactive UI screen that dispensed water and pills, and (2) a specialized mug that held both water and pills dispensed from the machine. Much of the feedback we got was about high level issues to consider, or details on the GUI that made the task more clear and helped to prevent error.



Of the changes mentioned in the previous section, the most important was putting a scanner in each individual pod and adding a hidden menu to the home screen with more options. Though these changes did not greatly impact the flow or order of our tasks, they made the interface more intuitive to both of our intended user groups.

For the first task, which is introducing a new medicine, the caretaker simply inserts the pill bottle into a pod, which has the scanner inside it to scan the label. A progress bar appears while the information is loading. The caretaker then looks over the scanned information and presses confirm or uses a voice command to finish the process. The caretaker can now also cancel the onboarding.

For the second task, the senior is alerted with persistent alarm to take their medicine. They can choose to snooze the alarm or start the medicine-taking process. The machine indicates when it is dispensing water and which specific pill. It guides them through the medicine taking process with both voice commands, lights on the machine, and icons on the GUI. After the senior takes their medicine and replaces the mug, the machine resets to the home screen.

A new feature to highlight that is critical to the design is the splitting of the Edit button into four features: Add Med, Edit Med, History and Settings. Our testing participants agreed that “Edit” is too vague, and features such as History should be added for safety and error recovery. These features were added to the home screen, and then hidden under a swipeable button so they are not pressed without thinking.

DIGITAL MOCKUP



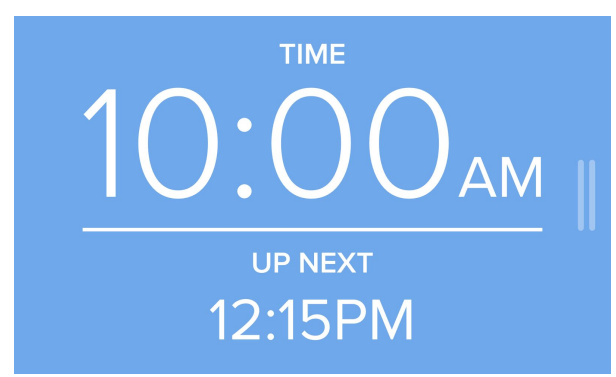
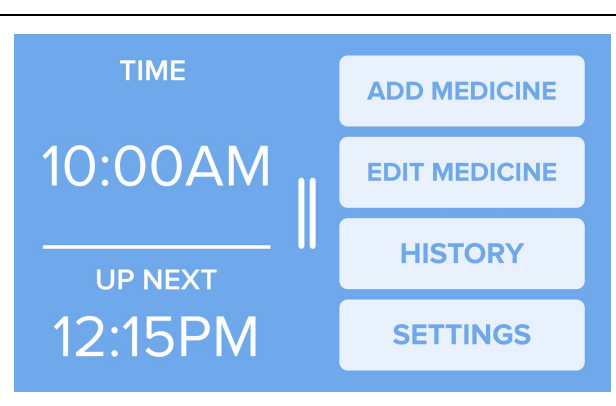
When we transitioned from paper to digital, we focused on making everything as bright and clean as possible to minimize distractions and error. We chose a light blue color because it is associated with safety and security, which we want for our users who trust our product with a critical component of their health.

It should also be noted that our product is more than just the GUI. It also includes a simple VUI that can accept input during interactive processes, such as a senior telling the machine they will “Take medicine in 15 minutes” rather than pressing “Snooze”. Lights on the medicine pods also

serve as an interface, and they can do things such as light up during the onboarding process when it is empty to indicate availability.

Our first task involves inputting new medications into the machine. To accomplish this, the caretaker and/or family member swipes left on the UI screen to bring out the options menu. They can then hit “add medicine”, and a prompt will come up to insert the medication bottle into the machine. After this, the machine scans the information on the bottle, and the user has the ability to edit the medication information if it is incorrect.

Our second task involves reminding and guiding the user to take their medicine at the appropriate time. Since our target audience is seniors with memory loss, we have tried to make the process of completing the task as intuitive as possible. When it is time for the user to take their medicine, the machine will alert the user via a series of voice reminders. Following this, the user has an option to snooze the reminder for a given period of time. Otherwise, the machine proceeds to dispense the medicine into a specialized cup designed specifically for the machine. After the user takes their medicine, they insert the cup back into the machine. If there is an error along the way (e.g. the senior forgets to insert the cup back into the machine), the VUI will keep reminding the senior until the error is corrected. The task is then completed.

 <p>The Home Screen UI features a blue background. At the top, the word 'TIME' is displayed in white. Below it, the current time '10:00 AM' is shown in large white digits. A horizontal white line separates the current time from the next medicine taking time, 'UP NEXT 12:15 PM', which is also in white. To the right of the time display, there are two vertical white bars indicating a swipeable area.</p>	<p>Home Screen Shows current time and incoming time for the next medicine taking.</p>
 <p>The Options UI features a blue background. On the left, the word 'TIME' is at the top, followed by '10:00AM' in large white digits. A horizontal white line separates this from 'UP NEXT 12:15PM' in white. To the right of the time display are two vertical white bars. Further right, there is a vertical stack of four light blue buttons with white text: 'ADD MEDICINE', 'EDIT MEDICINE', 'HISTORY', and 'SETTINGS'.</p>	<p>Options Swipe right from the indicator bar to bring out the options.</p>


Task 1: Adding a new medicine

	<p>From the home screen, caretakers can reveal a button menu by swiping or tapping the right side of the screen.</p>
	<p>To initiate adding medicine sequence, tap “Add Medicine”.</p>
	<p>Follow the instruction to open the lid as well as the pill bottle lid, then insert the medicine bottle.</p>
	<p>The screen and a voice will provide feedback that the medicine bottle was detected.</p>

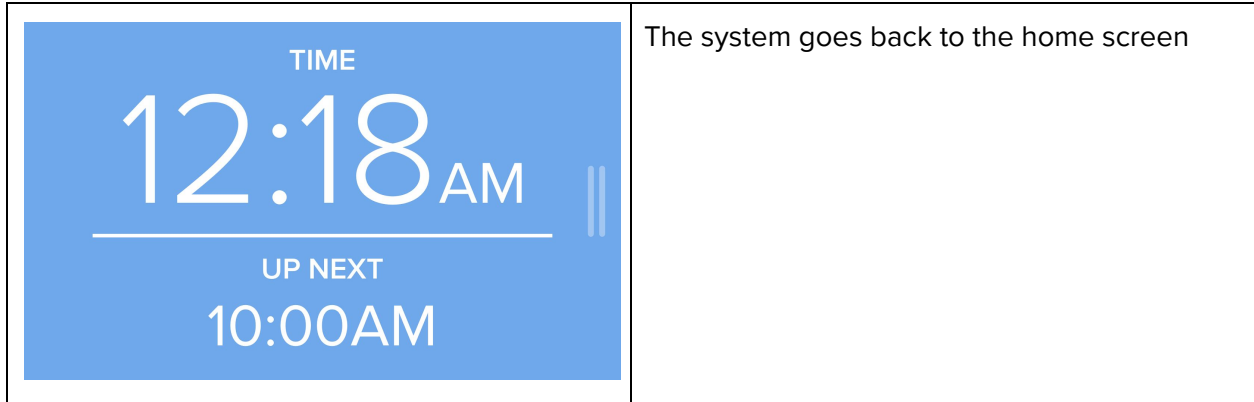
<p style="text-align: center;">Scanning medicine...</p> <p style="text-align: center;">80%</p> 	<p>A camera in each pod will scan the medicine bottle's label. A progress bar appears while the system is working.</p>													
<p>NAME: WARFARIN SODIUM TAB 5MG</p> <p>RX#: 106551</p> <p>INSTRUCTION: 2 TABLETS/ DAY</p> <p style="text-align: center;"> <input type="button" value="EDIT"/> <input type="button" value="CANCEL"/> <input type="button" value="CONFIRM"/> </p>	<p>The scanned information will appear on the screen. The user has the option to edit any incorrect information, cancel the input and confirm.</p>													
<p>MED. NAME WARFARIN SODIUM TAB 5MG</p> <p>RX# NUMBER 106551</p> <p>INSTRUCTION 2 TABLETS/ DAY</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33.33%;">1</td> <td style="width: 33.33%;">2</td> <td style="width: 33.33%;">3</td> <td rowspan="4" style="width: 33.33%; text-align: center; vertical-align: middle;"> <input type="button" value="CANCEL"/> <input type="button" value="CONFIRM"/> </td> </tr> <tr> <td>4</td> <td>5</td> <td>6</td> </tr> <tr> <td>7</td> <td>8</td> <td>9</td> </tr> <tr> <td>ABC</td> <td>0</td> <td>< x</td> </tr> </table>	1	2	3	<input type="button" value="CANCEL"/> <input type="button" value="CONFIRM"/>	4	5	6	7	8	9	ABC	0	< x	<p>In case of an error in input, the user touches the edit button. Then the user touches the field that they wish to change. This pulls up a keyboard if they want to change the medicine name or a numpad if they wish to change frequency or Rx number.</p>
1	2	3	<input type="button" value="CANCEL"/> <input type="button" value="CONFIRM"/>											
4	5	6												
7	8	9												
ABC	0	< x												
<p style="text-align: center;">Please remove medicine bottle</p>	<p>If the user wishes to cancel input, the screen prompts the user to take the medicine bottle out of the container.</p>													

<p>Medicine added</p>	<p>The system will provide feedback that the medicine add was successful.</p>
<p>Please close the lid</p>	<p>The system then prompts the users to close the lid.</p>
<p>TIME 10:00 AM UP NEXT 12:15PM</p>	<p>The system then goes back to the main screen.</p>

Task 2: Reminding and guiding user to take medicine

<p>Time to take medicine!</p> <p>OK</p> <p>SNOOZE</p>	<p>The system alerts the user that it is time to take medicine. It then give the user the option to take the medicine now, or snooze the system.</p>
<p>Remind me later in</p> <p>15 MINUTES</p> <p>30 MINUTES</p> <p>1 HOUR</p>	<p>If the user chooses to snooze the medicine, the system will ask how long it should wait before it starts to alert them again.</p>
<p>Preparing your medicine...</p>	<p>If the user clicks OK, the system starts picking out the pills that are needed at that time.</p>
<p>Filling water...</p> 	<p>The system then informs the user that it is filling the cup with water.</p>

<p>Please take medicine</p> 	<p>The system then prompts the user to take the medicine</p>
<p>Please place cup back here</p>  	<p>The system then detects when the cup has been taken out of the hub, and after waiting a couple of seconds prompts the user to put the cup back in the hub. It also gives the user the option to change the cup in case they want to clean the current cup.</p>
<p>Please place new cup here</p> 	<p>If the user chose to put in a new water cup, the system prompts them to put the new cup in.</p>
<p>Please refill water tank</p> 	<p>After the process, if there is insufficient water to fill up another cup, the system prompts the user to refill the water tank.</p>



DISCUSSION

Our design has progressed a long way since we first started the project. After trying to create a solution that broadly helped seniors, we learned that trying to create a design that solved a wide variety of problems can only help so much, and is likely to require some dramatic change in the user's environment. Although we tried very hard to make this solution more usable, we decided to step down a level and focus on one difficulty in the senior's life, rather than assisting them with all their tasks. We chose to focus on a task that was brought up multiple times in our research, which was taking medicine. This also went along with the need we discovered of caretakers wanting peace of mind while away, because caretakers we talked to revealed medicine to be a point of concern they had while away. Although the challenges of designing for a user group very different from ourselves still remained, this change in approaches was helpful in making our design more focused and accessible.

The most challenging part of the process was the limitation of having no learning curve and not using mobile apps. This manifested itself most while making changes based on the results of our usability tests. Although the feedback from our tests were helpful, we had to be very careful about extending our findings from the peers we tested to our actual user group. While thinking about the needs of seniors, we learned a lot about the tradeoffs made when making design decisions for the seniors. For example, including a snooze button for seniors to choose to take their medicine at a later time allowed them more control and freedom, but introduced more opportunity for error if they choose to snooze the alarm for too long.

Although our tasks themselves did not change, the methods through which they were completed changed somewhat. For instance, instead of assuming the user would want to explore the device, lift the lid on their own and learn that this started the onboarding medicine process, we added a labelled button that allowed the user to start this process. We also moved the scanner from the underside of the lid to inside each individual pod. We think this might be because the end goals of these tasks, to first introduce a new medicine then take the medicine, stay as a high priority regardless of the user's desires. For instance, even if the user does not want to take the medicine, they need to. By designing and iterating on our tasks to take as few steps on the user's part as possible, we believe that we will have a higher success rate for seniors to take their medicine, for every level of motivation to take medication.

We believe that a few more iterations upon our design could have been helpful. We received extremely useful feedback for both our paper prototype and our digital mockup, and taking the feedback into consideration, we revised our final design. However, there were some compelling points made during both of these phases that we believe would have made our design much more helpful for seniors, such as how the senior will have to get up and move to the machine when it's time to take medicine and it would be nice if they did not have to move. Opportunities to iterate further would give us more freedom to think about the limitations of the mode we have chosen and consider ways to address these higher level issues.

APPENDIX I: HEURISTIC EVALUATION CARDS

<p>Add way to put new medicine without having to lift Don't rely on experiment One person medication</p>	<p>What if just put pill bottle into pod Put camera/scanner into each pod to reduce one step - scan the bottle</p>	<p>(Maybe out of scope) Refilling pill bottles, change duration</p>
<p>Putting pills/bottle into the containers without scanning or going through the whole process. (Force user to scan bottle before being able to access the container area)</p>	<p>Edit button home screen Make it clean (have a screen?) for the edit button on the main screen and what it can do.</p>	<p>Error prevention What happens if pill bottle becomes empty? Need a way to prevent this from happening.</p>
<p>Help users recognize/diagnose/recover from errors If pill bottle is empty, what happens?</p>	<p>Aesthetic and minimalist design Why is glowing bottle slots necessary? Seems to be a distraction</p>	<p>Help users recognize diagnose and recover from errors When the scanner reads the incorrect # there's no prompt to check the info (use might not think to check bottle / screen for accuracy)</p>
<p>Recognition rather than recall "Put bottle in empty slot screen" Which bottle? User might forget which one they just scanned and put the wrong bottle in</p>	<p>User control and freedom What if user scans wrong bottle? Need a way to go back</p>	<p>Visibility of system status Does the scanner load the info almost instantaneous or is a process indicator needed?</p>
<p>Recognition rather than recall When editing info when scanner is wrong, maybe remind user when pill type they're inputting info for?</p>	<p>Flexibility and efficiency #7 If someone is inexperienced with system, might not know the correct actions. Consider more clearly indicating what actions to take rather than starting with "time to take pills"</p>	<p>Error Prevention Possible paths of adding meds without confirming / scanning data</p>
<p>Consistency and standards "EDIT" button at home screen might be better as "Settings" I currently interpret it as either editing the displayed time or the medications.</p>		

APPENDIX II: USABILITY TEST SCRIPT

Introducing test

Thank you for your time in helping us test our product, Pilltender. Our product is a pill dispensing machine that aims to help seniors with mild memory loss in their personal homes with their medication routine. I'd like to emphasize that today we are testing the usability of our product and not you, so keep in mind that there are no wrong moves and it would be most helpful if you do what you would do in real life. I'd also like to clarify that your name and other identifying information will not be included in our report, if that is of concern to you. Do you have any questions for me before we move on?

Task 1

For this first task you are acting as a caretaker for the senior with memory loss. Your task is to add this new medicine bottle into the machine. During this process, it'd be helpful for me if you explain your thought process, like tell me things that you see, what you expect to happen if you do a certain action, or if something surprises you. I won't be able to guide you unless you get really stuck. There is some narration that goes along with the device, so when I speak then I'm speaking for the device.

Task 2

For this task you are acting as the senior with memory loss. We'll say that you're not sure which medicine you need to take, but you know this machine is supposed to help you. Like the first task, I'd like you to explain your thought process, and I'll be talking for the machine.

Debriefing

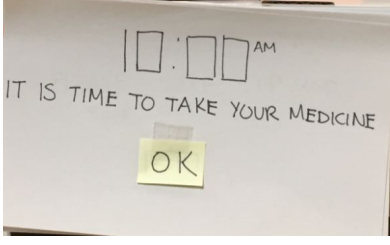
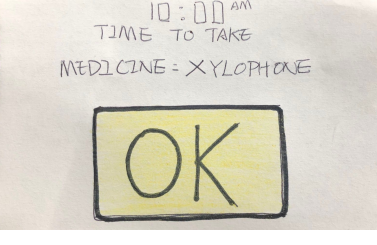

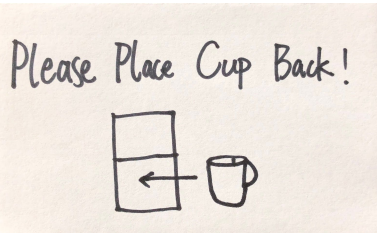
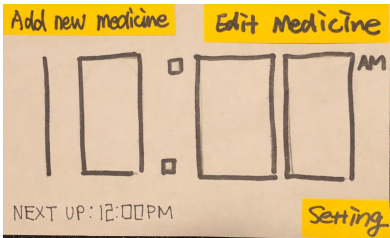
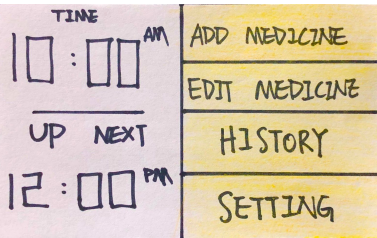
Thanks again for participating in our test!

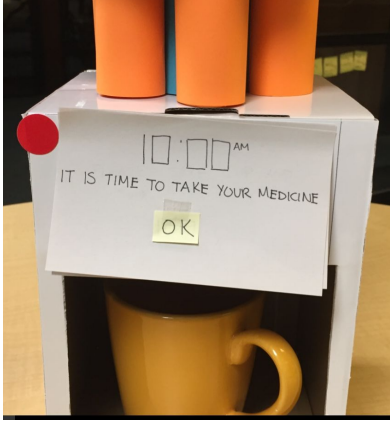
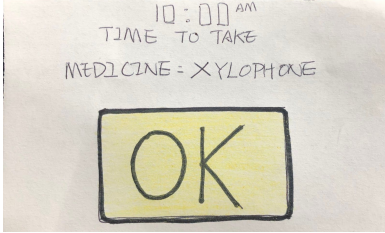
Did you have any overall thoughts about the tasks you just completed?

Do you have any other questions?

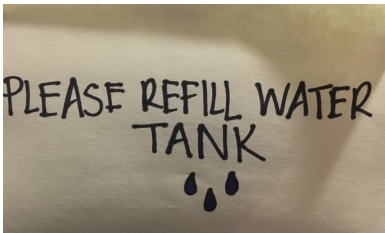
APPENDIX III: RESULTS FROM TESTING

Issues Identified From Usability Test 1

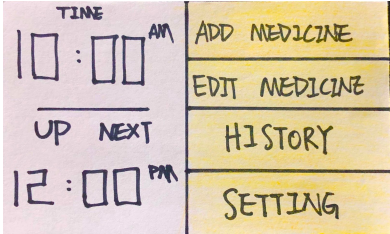
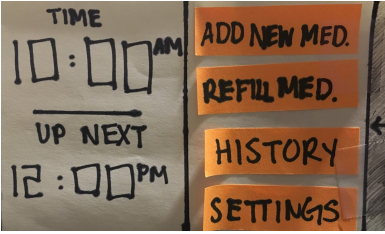
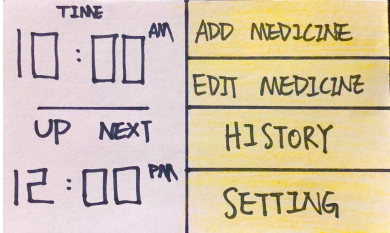
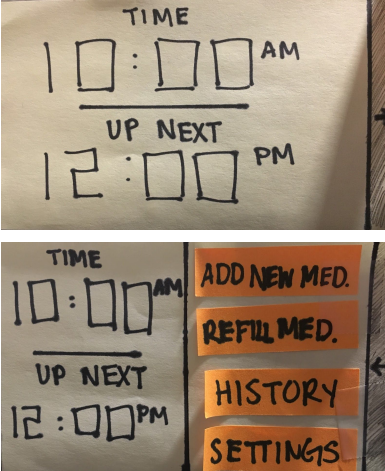
Before	Revision	Feedback from Eval
		<p>Efficiency of use (severity 2) Currently, some of the buttons and font sizes may be too small for seniors to read. This can be easily fixed by making them larger.</p>
		<p>User control and freedom (severity 4) Despite the machine telling them to return the cup, the senior may still forget to place the cup back or want to remove the cup to wash it. Without the correct cup, the user cannot take the pills next cycle. Notifications to place cup back should be more prominent.</p>
<p>Currently, the system speaks out instructions but does not accept voice commands as input.</p>	<p>Make spoken instructions into a simple VUI that can help user set up and edit medicines.</p>	<p>Flexibility of use (severity 2) Some people may prefer speaking commands rather than trying to figure out a graphical interface. A simple VUI should be implemented for those users.</p>
		<p>Recognize and diagnose errors (severity 3) Caretakers may want a record of which pills were dispensed when, just in case. This feature will be added to the GUI.</p>

		<p>Visibility of system status (severity 3)</p> <p>Although our research found that many seniors stay on one floor within their own homes, there is a chance that they still may not hear the notification. Notifications to take the medicine should be more prominent.</p>
n/a	<p>While this is a great point to consider, addressing it directly would be a level 1 difficulty.</p>	<p>Flexibility of use (severity 4)</p> <p>Some seniors may want to have the pills taken to them, rather than having to find the machine to use it.</p>

Issues Identified From Usability Test 2

Before	Revision	Feedback from Eval
n/a		<p>Help and documentation (severity 3)</p> <p>A concern was brought up that the user would not know when to refill the water tank when it is empty or close to being empty. To fix this issue, we added a message that alerts the user when the water tank is getting low and needs to be refilled.</p>

Issues Identified From Usability Test 3

Before	Revision	Feedback from Eval
		<p>Match between system and the real world (severity 2)</p> <p>The participant mentioned that the buttons were still confusing and could be condensed. They also mentioned that there is no intuitive way to refill medication. Therefore we changed the buttons to “add new med(icine)”, “refill med(icine)”, “history”, and “settings”. All the information previously in “edit medicine” are now under “settings”.</p>
		<p>Error prevention (severity 3)</p> <p>One issue that was brought up was that the senior might accidentally hit buttons on the home screen, become confused, and unknowingly mess up the system.</p> <p>To fix this, we added a general home screen that displays the time very prominently. This is what the senior will usually see when looking at the system. There is now a small arrow on the right side of the screen that is meant for the caretaker to edit information on the system. The caretaker can toggle between the two screens via the arrow button on the right side of the screen. This will hopefully minimize the amount of accidental errors from the senior.</p>