A Better User Interface for the Visually Impaired

Robert Bobkoskie
rbobkoskie3@gatech.edu

Abstract. As a Visually Impaired (VI) person, I find challenges in many tasks that a fully sighted person may not. Therefore, there is a large problem-space for task selection for my context. However, although the problem-space is extensive, it's not necessarily rich. That is, some of the tasks are simply out of scope for my condition, e.g., multi-tasking two or more visually intensive tasks. In selecting a task for this research, consideration was given to audiences that have a visual disability as well as those that do not. My research will involve evaluating an interface that offers users more than just pure visual interaction. This will include the interplay of haptic [1] and audible technologies for interface design.

1 QUALITATIVE EVALUATION

To obtain qualitative data, I plan to evaluate a verbal prototype. A verbal prototype is a low-fidelity prototype for exploring the feasibility of the concept. The objective of this prototype is to evaluate the relative function of the interface early in the design lifecycle to verify the design with respect to user expectations. The evaluation will answer the question: *Does the interface have the potential to meet user goals?*

The goals for qualitative evaluation align with the objectives of a verbal prototype:

1. **Performed early on to gauge user preference, what they like, don't like.**
2. **Provides a measure for the user experience. Is the interface usable, intuitive and easy to learn.**

1.1 Evaluation Plan

The qualitative data will be part of a pilot study with a user audience comprised of family and friends. The data will be *synchronous, think aloud feedback* obtained in a *field* setting. In this case, *field* is loosely defined as my residence. The results will be recorded by notetaking during the individual sessions with each subject:

[1] Haptic Technology

- **Spouse**
- **Daughter**
- **Friend-1**
- **Friend-2**

1.2 Evaluation Content: Think Aloud User Feedback

The following questions will be used to provide definition and get feedback from the user about the prototype:

1. **Let's discuss cooking with a microwave.**
   - *What task you most often use a microwave to perform?*
   - *Do you ever get frustrated when performing this task?*
   - *While using a microwave, are there any other tasks you perform?*
   - *Can you program your microwave in the dark?*
   - *What are you thinking about as you program the microwave? Do you have to think about how to program the microwave, or is this intuitive?*
2. **I'm considering a microwave interface that will be used to program the microwave for cook and defrost and have a way to set the time duration for either of those two options. Do you feel like those two options are enough to accomplish your needs for using the microwave?**
   - *Cook and defrost are the only options. Is this sufficient, or do you prefer more options?*
   - *Would the addition of more options make this interface easier or more challenging for you to perform your favorite task?*
3. **The concept for setting the time is novel. It will not use digits [0-9] to enter the duration. Think about setting the volume on a YouTube video. You drag the volume button left or right to decrease or increase the volume respectively. Similar to setting the volume on a YouTube video, this interface will have a button that can be dragged to set the time. However, where the YouTube volume selector only moves in the horizontal plane, this interface will have a button that moves both horizontally and vertically, as well as any angle between 0 and 90 degrees. Consider your high school math class, the Cartesian coordinate system. This application will have a button at the origin [0, 0] which can be moved**:
   - *In a positive horizontal direction to increase the time by seconds.*
   - *In a positive vertical direction to increase the time by minutes.*

- *In a negative horizontal direction to decrease the time by seconds.*
- *In a negative vertical direction to decrease the time by minutes.*
- *With a positive slope to increase the time by minutes/seconds. The steeper the slope, the greater the increase by the minute.*
- *With a negative slope to decrease the time by minutes/seconds. The steeper the slope, the greater the decrease by the minute.*
    * *Please use this pen and paper to draw the interface I've just described.*
    * *Using the diagram you've depicted, can you show and tell me how you would set the time using this interface?*
    * *Does this seem easier or more difficult that using a [0-9] keypad to program the time?*
    * *We're concluding this session. before we part, and **we're all warmed up - pun intended**, tell me about your goals for a microwave interface?*
    * *Thanks for your time today, do you have any other thoughts or questions for me?*

1.3 Conclusion: Think Aloud User Feedback

This section will explore the relationship between the *Think Aloud* evaluation and the requirements gathered during needfinding and captured in the data inventory. Refer to the **Data Inventory** shown in figure 3 in APPENDIX.

Think aloud feedback will focus on user feedback more than teaching. For example, the feedback from having the subjects *draw the interface* will be useful in gauging user perception of the interface. Refer to Evaluation Content: Think Aloud User Feedback, item 3. In addition, Evaluation Content: Think Aloud User Feedback will augment the data inventory, though with a smaller sample-set of participants. The feedback from this exercise will provide insight on:

- **What are the user goals?**
  There are specific questions about the subjects goals. I plan to listen and, if necessary, provide soft coaching
- **What does the user need?**
  *Participants will be **encouraged** to consider and verbalize their needs.*
- **What are the user tasks?**
  *I expect confirmation of the tasks: **Cook, Defrost**. I expect some additional*

feedback on other tasks, perhaps stop-watch/timer.

- **What are the subtasks and how does the user accomplish the subtasks?** *I'm excited about this question, as it was uncovered during initial needfinding activities. I'm uncertain what the subjects will reveal.*

When conducting *Think Aloud* studies, one must consider selection and confirmation biases [2]. These biases can be introduced as participants become more thoughtful while experimenting with prototypes and thinking about responses. Thus, they will become more of an expert during the evaluation. To address this, there will be more questions than answers from me during the evaluation. It should be noted that most users are *experts* with microwave interfaces and, although the interface I'm designing is novel, the learning curve for the subjects will follow a Sigmoid Function [3] and be rapid after a warm-up period.

2 EMPIRICAL EVALUATION

The goal of this empirical analysis is to obtain quantitative data to objectively compare user efficiency when programming microwave interfaces.

2.1 Empirical Evaluation: Experimental Method

To capture this data, I plan to conduct an *within-subjects* experiment involving the two treatment. The participants will be randomly assigned into two groups with each participant designated a random order to evaluate each treatment. The benefits of utilizing an *within-subjects* approach:

- **Given a limited participant pool, twice as much data can be gathered.**
- **Allows for evaluation of within-subject comparison, which identifies how each participant was affected, rather than the group as a whole.**
- **The treatments will not be complex, thus participants time in each treatment is expected to be short.**

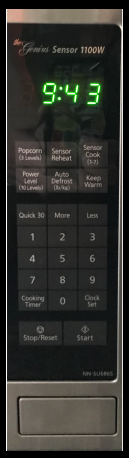
2.2 Empirical Evaluation: Control and Experimental Data

In order to gauge user efficiency in programming a microwave interface, participants will be asked to program a microwave to cook an item for 12:35 and 7:00 minutes and to defrost an item for 49 and 8 seconds. The time for cook and

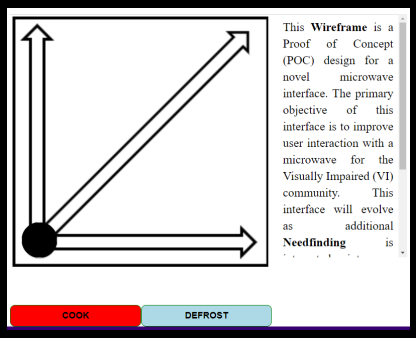
[2] Biases

[3] Sigmoid Function

defrost are deliberately chosen for values containing unique integers of different length [12:35, 49] as well as a single integer to the exact minute and second [7, 8] respectively.



(a) Treatment 1: Standard Microwave Interface



(b) Treatment 2: Wireframe Prototype

Figure 1: Treatments: Standard Vs. Prototype Microwave Interfaces

Choosing the time in this manner is a *control variable* designed to minimize the effects of variables that are dependent on the interface, i.e., the difference in the timing controls, see figure 1 on page 5. This approach will also serve to minimize biases when programming the interface. Entering a time with a single integer, e.g., **7:00** minutes may introduce a bias to the treatments. Indeed, entering a time with unique integers, e.g., **12:35** may also introduce a bias. Conversely, utilizing both time formats will negate the effects of using either alone, thus, minimizing bias.

1. **Standard Microwave Interface:**
   How long does it take a participant to cook an item for 12:35 minutes?
   How long does it take a participant to cook an item for 7:00 minutes?
   How long does it take a participant to defrost an item for 8 seconds?
   How long does it take a participant to defrost an item for 49 seconds?
2. **Microwave Interface Prototype as defined by a Wireframe [4] hosted on GitHub.**
   How long does it take a participant to cook an item for 12:35 minutes?
   How long does it take a participant to cook an item for 7:00 minutes?
   How long does it take a participant to defrost an item for 8 seconds?
   How long does it take a participant to defrost an item for 49 seconds?

[4] Microwave Wireframe

2.3 Empirical Evaluation: Hypothesis Testing

The *null hypothesis* is that the time to program a microwave will be *equal* for the two treatments. The *alternative hypothesis* is that the time to program a microwave for treatment 2 will be shorter than that of treatment 1. Thus, the proposed design will allow users to be more efficient in programming a microwave. The *alternative hypothesis* will be accepted if the results are *statistically significant*, i.e., there is less than a five percent chance that the difference in efficiency between the treatments could have arisen by random chance.

2.4 Empirical Evaluation: Conclusion, Lurking Variables and Bias

A *lurking variable* is a variable that is unknown and not controlled for. It may have a significant effect on the variables of interest, e.g., the amount of *time* it takes to program the interface. The experimental control that was defined in Empirical Evaluation: Control and Experimental Data can address lurking variables that may arise from a user programming the interface. For example, programming single integers for a *cook time* may introduce a lurking variable where the buttons of the interface may *stick or jam*.

Some potential lurking variables that may be introduces are:

- **Treatment order for subjects participating in a within subjects design. Consistently assigning subject to experience one of the treatments first can introduce a lurking variable based on a static ordering of treatments.**
  *Account for this lurking variable by **randomly assigning the order** for participation in treatments.*
- **The differences in *human abilities* for each participant, i.e., vision, haptic dexterity and human cognition.**
  *Account for this lurking variable by **randomly assigning the order** for participation in treatments.*
  *Account for this lurking variable by **randomly assigning** participants to treatments.*

To moderate the effect of lurking variable during analysis, regression analysis of the data will be employed.

3 PREDICTIVE EVALUATION

A hand drawn paper prototype, refer to figure 2 was created to evaluate user interaction with the interface.

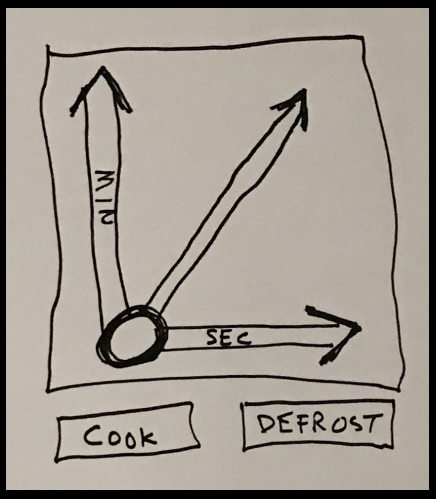


Figure 2: Paper Prototype: Touchscreen Interface

This paper prototype has the potential to also serve as a *card based cognitive walkthrough* for *predictive evaluation*. To perform this evaluation, I'll step through the process of interacting with the paper prototype, mentally simulating a *novice user* interacting with the interface to accomplish the goals of programming the microwave to *cook* and *defrost*. Tasks associated with the goals will be explored in the context of bridging the users *gulfs of execution and evaluation*.

3.1 Cognitive Walkthrough

1. **Program the microwave to cook an item for 12:35 minutes.**
   ***Gulf of Execution**: A user will consider how to enter the time. They may touch the arrows, or even the disk at the origin of the second/minute axis. In order to bridge the gulf of execution, the user will be allowed to experiment in order to discover operations to execute the task. After entering the time, a user will then hit the **Cook** button, however, this button has **affordances** that tell a user what to do, thus bridging the gulf of execution.*
   ***Gulf of Evaluation**: While entering time, a user will look for feedback on the time duration they entered. Audio feedback to notify the user of potential actions as well as button functionality could help to bridge the gulf of evaluation.*
2. **Program the microwave to defrost an item for 8 seconds.**
   ***Gulf of Execution**: Similar to **cook**, a user will consider how to enter the time. They may touch the arrows, or even the disk at the origin of the second/minute axis. In order to bridge the gulf of execution, the user will be allowed to experiment in order to discover operations to execute the task. After entering the*

*time, a user will then hit the **Defrost** button, however, this button has **affordances** that tell a user what to do, thus bridging the gulf of execution.*
***Gulf of Evaluation**: While entering time, a user will look for feedback on the time duration they entered. Audio feedback to notify the user of potential actions as well as button functionality could help to bridge the gulf of evaluation.*

4 PLAN FOR EVALUATION

Future work will involve executing the plans for Qualitative Evaluation defined in QUALITATIVE EVALUATION and Predictive Evaluation defined in PREDICTIVE EVALUATION.

The rationale for choosing these forms of User Evaluation are:

- **Qualitative evaluation can provide formative, early cycle evaluation of what the user *thinks* about the interface.**
- **Predictive evaluation can provide insight on user operations to accomplish goals using the interface in order to bridge the users gulf of execution. Feedback can also be simulated and analyzed to bridge the gulf of evaluation.**
- **At this stage of the design process, the physical prototype is not developed enough to support empirical evaluation.**

5 APPENDIX

Data Inventory	Needfinding 1	Needfinding 2	Needfinding 3
Who are the users [age, gender, hobbies]?	Survey response show that most users prefer to visually intact with microwave interfaces: Visual: 16, Haptic: 9, Audible: 0 and have an average age of 33.88 +- 8.86485194462	I was not able to observe enough participants to qualitatively answer this question	This was not part of the data inventory for this needfinding plan
Where are the users?	This was not part of the data inventory for this needfinding plan	This was not part of the data inventory for this needfinding plan	This was not part of the data inventory for this needfinding plan
What is the context of the task?	From the survey responses, the user context is to Re-Heat or Cook food using the Microwave control panel as their preferred interface	This was not part of the data inventory for this needfinding plan	I was not able to observe enough reviews to qualitatively answer this question
What are the user goals?	User goals are to cook/heat/defrost food by interacting with the "native" microwave interface	This was not part of the data inventory for this needfinding plan	I was not able to observe enough reviews to qualitatively answer this question
What does the user need?	The survey response did dhow some level of dissatisfaction with existing microwave interfaces. From this data, I can cycle through additional needfinding, requirements and prototyping	I was not able to observe enough participants to qualitatively answer this question	User reviews corroborated dissatisfaction with programmable microwave interfaces. Conversely, some reviews preferred a more simplistic interface.
What are the user tasks?	Data from the survey show user tasks: Cooking: 14, Defrosting: 10, Re-heating: 21, Timer: 4	This was not part of the data inventory for this needfinding plan	This was not part of the data inventory for this needfinding plan
What are the user subtasks?	NA for this needfinding plan	NA for this needfinding plan	NA for this needfinding plan

Figure 3: Data Inventory