Consider Cognitive Load to Improve Interface Design

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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 NEEDFINDING RESULTS AND DISCUSSION: SURVEY

Data in this section was culled from a survey[2] distributed to this class as well as two YouTube channels[3][4] that have a large VI audience. Refer to Appendix: Survey Questions to view the survey questions.

1.1 Remediate Bais

My goal was to minimize survey response, measurement and sampling biasses[5]:

- Acquiescence Bias: The tendency of respondents to agree with whatever the survey question is asking or stating. For example, survey questions of the type agree/disagree more often solicit an agree response.
  I addressed this bias by creating questions that did not imply there's a "right" answer.
- Undercoverage: Undercoverage occurs when some members of the population are inadequately represented in the sample.

[1] Haptic Technology
[2] PeerSurvey
[3] Blind to Billionare
[4] Cayla with a C
[5] Bias

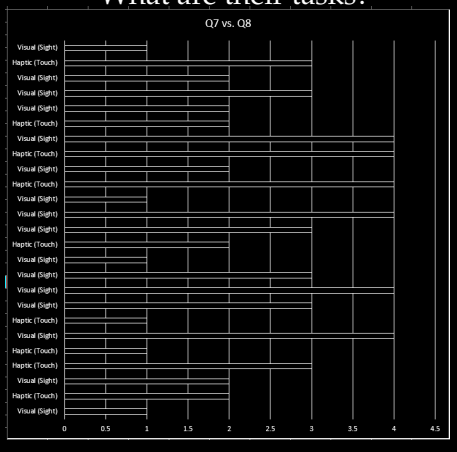
I addressed this bias by distributing the survey to both VP and non-VP populations.

- Leading Questions: The wording of the question may be loaded in some way to unduly favor one response over another. For example, a satisfaction survey may ask the respondent to indicate where she is satisfied, dissatisfied, or very dissatisfied. By giving the respondent one response option to express satisfaction and two response options to express dissatisfaction, this survey question is biased toward getting a dissatisfied response.
  I addressed this bias by creating questions that had choices that were evenly distributed.
- Social Desirability: Most people like to present themselves in a favorable light, so they will be reluctant to admit to unsavory attitudes in a survey. Instead, their responses may be biased toward what they believe is socially desirable.
  I addressed this bias by not mentioning my visual disability in the survey..

1.2 Summary and Analysis

The following plots depict the data inventory for users of microwave ovens:

- Who are the users?
- What is the context of the task?
- What are their goals?
- What are their tasks?



(a) Microwave Intgeraction vs. User Issues

(b) Microwave Usage vs. User Tasks

Figure 1: Needfing Plan 1: Data Inventory

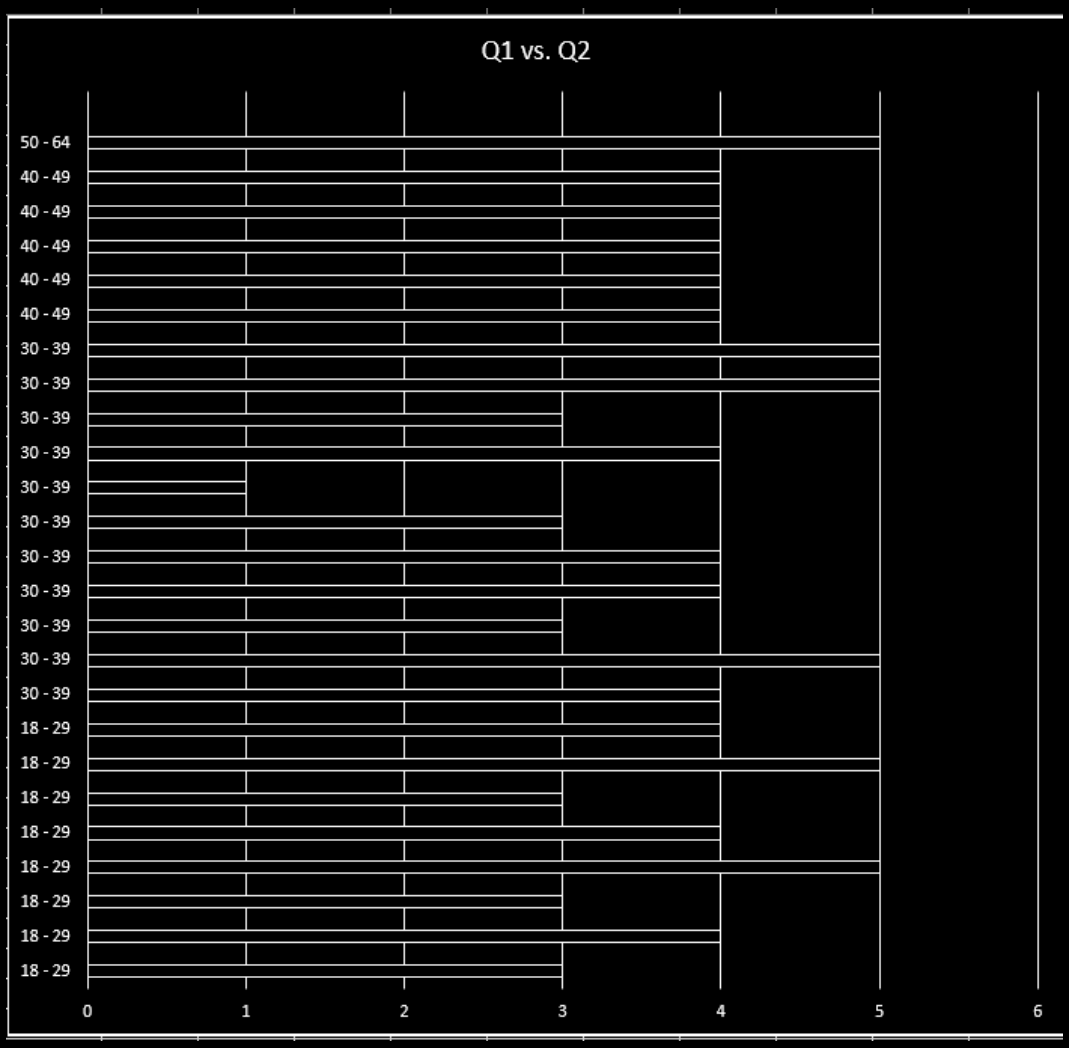


Figure 2: User Age vs. Microwave Usage

Results from the survey were analyzed using python to generate statistics and excel for plots. Refer to Appendix: Responses to Questions to view the raw data responses to the survey questions. Refer to Appendix: Full Size Plots to view larger images of figure 1.

The average age of respondents was 33.88 with a standard deviation of 8.86. This question was asked in order to infer how user age may impact interface design. For the question ”Do You Have Any Issues With Programming a Microwave Through its Native Interface, i.e., Control Panel?”, the average response was 2.48. This was on a scale from [1, ”Very Frequently”] to [5, ”Never”]. The result is closer to ”Very Frequently”, implying there is some dissatisfaction with the current

design of microwave interfaces. For the question "How Often Do You Use a Microwave Oven?", the average response was 3.88. This was on a scale from [1, "Very Frequently"] to [5, "Never"]. Here the results show a tendency for more occasional microwave oven usage.

2 NEEDFINDING RESULTS AND DISCUSSION: EVALUATION OF EXISTING USER INTERFACES

To obtain data for the evaluation of microwave interfaces, see figure 3 on page 4. I conducted a study of my interaction with various interfaces from a floor sampling of microwaves in an electronics store. I also observed other user interaction. It took some time, as not many people were shopping, and even fewer were looking at microwaves. Most users opened the door and did not interact too much with the interface. I didn't gain as much from observing other users as I'd anticipated. Since physically observing individuals interacting with microwave interfaces didn't yield useful data, I searched YouTube for users interacting with microwave ovens. I found this funny Video[6]. Though it is comical, it did open my thoughts to consider more feedback that a microwave interface currently provides. Perhaps, rather than violently spark when a metal object is heated, a microwave might sense a metal object is placed inside prior to starting the oven.

(a) Microwave: Digital Interface

(b) Mcrowave: Retro Interface

Figure 3: Microwave Interfaces

2.1 Remediate Bais

The following biases were addressed:

- Observer Bias: Originates from observing or recording information where

[6]Funny Microwave Video

cognitive biases (including preconceptions and assumptions) can affect how a subject is assessed.
I addressed this bias by adding a self-evaluation of microwave interfaces. However, this may have introduced a voluntary response bias (see below).

- Voluntary Response Bias: Occurs when sample members are self-selected volunteers. The resulting sample tends to overrepresent these participants.
To alleviate this bias, I planned to observe at least ten users interacting with microwave interfaces. This was ambitious, as I only observed three people and only one person interacted with the microwave interface. Searching YouTube for videos also did not provide meaningful results for user interaction with microwave interfaces.
- Learner Bias: A user who has practice with a task has learned how to perform the task efficiently. Their gulfs of evaluation and execution have narrowed from that of a novice user.
To minimize this bias, I planned to observe users who planned to purchase a microwave at an electronics store. I thought these users may interact with the microwave interface prior to purchase. These users would be novices and, in theory, have large gulfs of evaluation and execution. This did not work out as planned, as the sample set was too small.

2.2 Summary and Analysis

I found out that observing people performing some tasks is more challenging than expected. Some behaviors, such as fitness training and playing basketball are more favorable for "people watching". A narrowly defined task such as programming a microwave is more challenging to observe. Another issue is that I wanted to observe novice users, thus further dwindling an already reduced set of potential participants. Overall, this exercise did not fully address my needs.

3 NEEDFINDING RESULTS AND DISCUSSION: ANALYSIS OF PRODUCT REVIEWS

I perused various product review sites to glean information on user evaluation of microwave ovens (refer to Needfinding: Analysis of Product Reviews to see reviews). I was interested in user reviews of the interface3 on page 4, and not the cooking time, durability or warranty.

3.1 Remediate Bais

The following biases were addressed:

- Voluntary Response Bias: Occurs when sample members are self-selected volunteers. The resulting sample tends to overrepresent these participants.
  To alleviate this bias, I found a broad spectrum of product reviews from two review sites.
- Positive Review Bias: Can occur if the reviewer has an incentive to provide a positive product review.
  Since I was not looking to purchase the product, I was not seeking out positive reviews. I was actually looking for reviews where the user may have had difficulties with the user interface, which, in most cases, correlated with a negative review.

3.2 Summary and Analysis

This needfinding exercise provided useful information about user interaction with microwave interfaces. I was able to determine the potential for other users to experience some of the same challenges with digital microwave interface (see figure 3a on page 4) as I do. Conversely, some users seemed to prefer the simple analog style of interface (see figure 3b on page 4) that I feel would benefit the visually impaired community.

4 DATA INVENTORYS

Table 1 describes the data inventory for my three needfinding plans. Needfinding plan 1 (survey) enriched the data inventory. Further studies would more directly question users for their goals and subtasks.

Needfinding plan (Evaluation of existing user interfaces) was not as successful as I'd anticipated. I didn't consider how the experiments narrow scope would limit the data inventory. Since my evaluation of user interfaces is highly biased, I needed to include the observation of other users to mediate voluntary response bias. Future work would eliminate this plan and perhaps conduct interviews.

Needfinding plan (Analysis of product reviews) was moderately successful. User reviews of microwaves provided some evidence of user dissatisfaction with existing microwave interfaces. Some users also preferred interfaces with minimal features and haptic components that I feel would benefit the visually impaired community.

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

Table 1: Data Inventory for Needfinding Plans

5 DEFINING REQUIREMENTS

Requirement for a novel microwave interface:

- Functionality [What the interface can do]
  Functional requirements would UTILIZE fewer controls with more haptic features. For example, eliminate the touchpad interface and replace it with a dial and tactile buttons. Include more audible features to give the visually impaired a second modality for interaction. Implement Artificial Intelligence (AI), via a smartphone app or digital assistant (Alexa).
- Usability [How user interactions work]
  Allow functional requirements that are intended for visually impaired users to be disabled for non-visually impaired users. Utilizing AI could narrow the gulfs of execution and evaluation, thus making the interface more invisible for users.
- Learnability [How quickly can the user learn to use the interface]
  AI could improve learnability by suggesting user input based on user behavior and data learned from the large(r) population of users. Haptic feedback such as a vibrations or more tactile controls would enhance a users learning through multiple modalities of information.
- Accessibility [Who can use the interface]
  Requirements shall improve user experience and satisfaction with microwave interfaces for visually impaired users.
- External project requirements:
  - Compatibility: *The interface must be compatible for both visually impaired and non-visually impaired users.*

6 CONTINUES NEEDFINDING

Additional needfinding would better address user goals and subtasks. Understanding user behavior while using a microwave would better define these components of the data inventory. Additional survey questions:

- What activities are you performing while using a microwave (NA if None)?
- What are your goals for using a microwave (Less/More features)?

Since participant observation was limited, I would conduct interviews to confirm survey responses. The unstructured nature of interview question/response will both support and augment the data inventory.

7 APPENDIX

The appendix presents raw data derived from needfinding exercises.

7.1 Appendix: Survey Questions

Feedback was solicited for the following survey questions:

A Better User Interface for Performing Common Household Tasks *The objective of this survey is to collect and evaluate the perspective of users who use a common household appliance, the microwave oven. All responses will be used to evaluate design principles for a better user experience with using a microwave oven.*

- Select Your Age
- How Often Do You Use a Microwave Oven?
- What Tasks Do You Perform With a Microwave? (Choose All That Apply)
  - Cooking
  - Defrosting
  - Re-heating
  - Timer (Stopwatch)
  - Don't use a Microwave
- How Do You Program a Microwave, i.e., Set Time, Start? (Choose All That Apply)
  - Control Panel on the Microwave
  - Home Assistant, i.e., "Alexa"
  - Smartphone Application
  - Don't use a Microwave
- For Your Preferred Method for Programming a Microwave, Please Enter Your Method (Control Panel, Home Assistant, Smartphone App) and Describe Your Level of Satisfaction With this Method.
- What is Your Preferred Way to Interact With Applications?
  - Visual (Sight)
  - Audible (Sound)
  - Haptic (Touch)
- Do You Have Any Issues With Programming a Microwave Through its Native Interface, i.e., Control Panel?
- If You Have Any Issues With Programming a Microvalve, Please Provide a Brief Description.

7.2 Appendix: Responses to Questions

Select Your Age: 33.88: 8.86485194462

18 - 29
30 - 39
30 - 39
30 - 39
30 - 39
30 - 39
18 - 29
18 - 29
40 - 49
30 - 39
30 - 39
50 - 64
40 - 49
18 - 29
40 - 49
18 - 29
30 - 39
30 - 39
40 - 49
30 - 39
40 - 49
18 - 29
30 - 39
18 - 29
18 - 29

What is Your Preferred Way to Interact With Applications?

Visual (Sight)
Visual (Sight)
Visual (Sight)
Visual (Sight)

Haptic (Touch)
Visual (Sight)
Haptic (Touch)
Visual (Sight)
Haptic (Touch)
Visual (Sight)
Visual (Sight)
Visual (Sight)
Visual (Sight)
Haptic (Touch)
Visual (Sight)
Haptic (Touch)
Haptic (Touch)
Visual (Sight)
Visual (Sight)
Haptic (Touch)
Haptic (Touch)
Visual (Sight)
Visual (Sight)
Haptic (Touch)
Visual (Sight)

Do You Have Any Issues With Programming a Microwave Through its Native Interface, i.e., Control Panel?: 2.48

1
4
3
1
2
3
2
2
2
4

1
1
2
3
3
1
4
2
2
4
3
4
4
1
3

What Tasks Do You Perform With a Microwave? (Choose All That Apply)

Re-heating
Cooking;Defrosting;Re-heating;Timer (Stopwatch)
Cooking;Defrosting;Re-heating
Cooking;Defrosting;Timer (Stopwatch)
Re-heating
Cooking;Defrosting;Re-heating
Cooking;Defrosting;Re-heating
Cooking
Cooking;Re-heating
Re-heating
Don’t use a Microwave
Cooking;Re-heating;Timer (Stopwatch)
Cooking;Defrosting;Re-heating;Timer (Stopwatch)
Defrosting;Re-heating
Defrosting;Re-heating
Re-heating
Cooking;Re-heating

Defrosting;Re-heating
Cooking;Defrosting;Re-heating
Re-heating
Cooking
Re-heating
Cooking;Re-heating
Cooking;Re-heating;Don't use a Microwave
Re-heating

How Do You Program a Microwave, i.e., Set Time, Start? (Choose All That Apply)

Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Don't use a Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave
Control Panel on the Microwave

Control Panel on the Microwave
Control Panel on the Microwave

How Often Do You Use a Microwave Oven?: 3.88

3
4
5
3
4
4
4
3
4
3
1
5
4
5
4
4
4
3
4
5
4
3
5
5
4

For Your Preferred Method for Programming a Microwave, Please Enter Your Method (Control Panel, Home Assistant, Smartphone App) and Describe Your Level of Satisfaction With this Method.

Control Panel - sufficient
control panel, pretty satisfied
Control panel, pretty satisfied
I only use the control panel because I don't have a microwave that uses any other method. It works but can be improved.
control panel
Without reading instructions, I'm not sure how long or at what level to cook the food.
Control panel, satisfied (4 out of 5)
Control Panel and it gets the job done. So neutral.
control panel
Control Panel - Not Satisfied
n/a
Control panel, microwave is my lifeguard, means my day today handy appliance
Control Panel or touch screen with guided pre-set options... Satisfied
I must be a caveman, but the only way I use the microwave is pushing buttons on Control Panel. It's pretty great
Control panel, satisfied
Control Panel ok
Control Panel, my microwave's panel is not set up for efficient operation for common tasks
Control Panel, works just fine
Control Panel
control panel
Control panel
I only have a traditional control panel microwave, and I'm not very satisfied with the interface
Control Panel - Not completely satisfied
Control Pane, EXTREMELY satisfied ;)
Control Panel, Somewhat Satisfied

If You Have Any Issues With Programming a Microvalve, Please Provide a Brief Description
Confused about order of operations when setting both cooking time and power level.

Figuring out how to defrost food.
Presets that microwaves come with never work for me (ex. meat, vegetables, etc.)
N/A
Never can figure out the setting I need to select to properly reheat something. Most of the time I start/stop it frequently and test the temperature.
My microwave is my closest and cutest friend and never troubles or bothers me at all....so far so good
Sometimes (usually) the popcorn button burns my popcorn
Issue with programming microwave can be if the button does not respond to pressing (didn't hit the correct part of it) and it requires me to hit a bunch of buttons to frequently do the same thing, and the "presets" are unreliable for making popcorn, etc.
NA
Not sure what is the default button functions' Sometimes confused which buttons I should use to warm food. Slow, Too many buttons, Not sure how long different items should be cooked for The defrost options are not very clear
button click not detected first time

7.3 Appendix: Full Size Plots

Larger images of figure 1 on page 2.

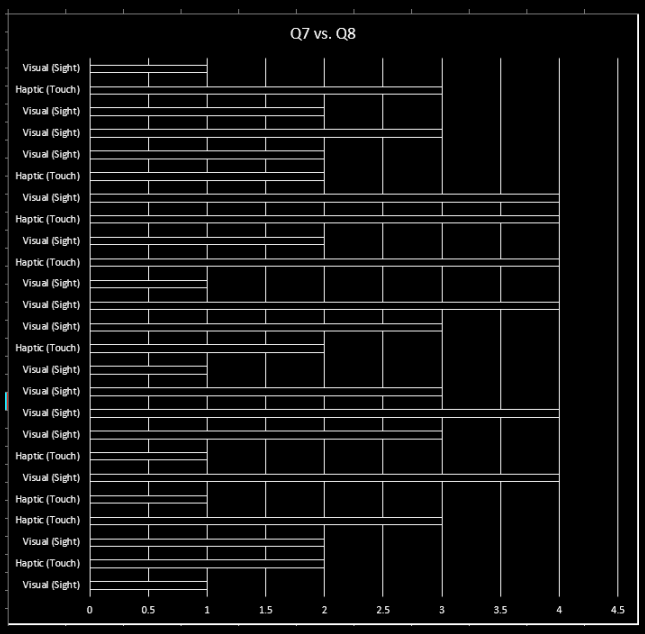


Figure 4: UMicrowave Intgeraction vs. User Issues

Microwave Usage (Frequency and Task)

5	Cooking;Re-heating;Timer (Stopwatch)
4	Cooking
4	Cooking;Defrosting;Re-heating
4	Defrosting;Re-heating
4	Cooking;Defrosting;Re-heating;Timer (Stopwatch)
4	Cooking;Re-heating
5	Cooking;Re-heating
5	Re-heating
3	Defrosting;Re-heating
4	Cooking;Re-heating
1	Don't use a Microwave
3	Re-heating
4	Cooking;Defrosting;Re-heating
4	Re-heating
3	Cooking;Defrosting;Timer (Stopwatch)
5	Cooking;Defrosting;Re-heating
4	Cooking;Defrosting;Re-heating;Timer (Stopwatch)
4	Re-heating
5	Cooking;Re-heating;Don't use a Microwave
3	Re-heating
4	Re-heating
5	Defrosting;Re-heating
3	Cooking
4	Cooking;Defrosting;Re-heating
3	Re-heating
Q2	Q3

Figure 5: Microwave Usage vs. User Tasks

7.4 Needfinding: Analysis of Product Reviews

"We had to replace our old microwave after 9 years of faithful service and found the LG NeoChef. It was nice that they offered a white one as it matched our kitchen. The touch controls are simple and easy to use and **offer a number of additional features but to be honest, our main use is just pressing the start button a few times to get up to the desired time** and off it goe."[7]

"Functionally quite sound. Heats food efficiently and evenly with minimal noise. **The ease of use could be improved. Can be a little frustrating** attempting to access the lesser used functions under the door."[8]

"At the moment its still new so it heats food up quickly even within a minute I was amazed as I thought LG I was a bit hesitant when buying it. But it has so many features and for busy bees you can **download an app to turn it on and heat your food just before you get home all from your phone**."[9]

" bought the smallest microwave I could fine to have in our galley space. Despite its size, the microwave surprisingly is able to fit larger items with ease. **We only use our microwave for reheating food and nothing else** so it fits our purpose."[10]

"**I have one serious problem with it, partly due to its design, and partly due to a neurological condition which leaves me with little dexterity and no sense of touch in my hands**. The turntable has the same kind of design as the one in my previous microwave with the glass platter molded to fit on top of a central turning shaft and a flimsy plastic ring with rollers that fits loosely inside a depression in the floor.' [11]

"UPDATE: After three or four days I must say that the cheery color, **simple DIAL. Feature**, and the powerful wattage has really made me happy."[12]

[7] ProductReview.com
[8] ProductReview.com
[9] ProductReview.com
[10] ProductReview.com
[11] Amazon.com
[12] Amazon.com