Project : CS6750

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1 INTRODUCTION

A car infotainment UI as it exists remains extremely buggy and unintuitive. A lot of times, they try to cram all functionality into a small box and the result is a mess that is so hard to understand that most users have a fixed preset that they use and refuse to go beyond that unless absolutely necessary. They are also often placed in hard to reach sections that makes controlling them a nightmare. When driving, fidgeting with the controls is the last thing that should be on the driver's mind. The image below shows the stereo systems in a Nissan Pathfinder.

Figure 1—Stereo in a Nissan Pathfinder

However the stereo functionality can be really basic. Most car systems provide 3 modes. Radio (FM/AM), Aux and Bluetooth and all three modes share the similar functionality in between them. Most users do not need to find the equaliser functionality on the dash and the UI can be optimised to be intuitive and invisible. So I would like to focus on the redesign of a car stereo for the above three modes within similar dimensions and redesign it without any additional cost or space.

USER TYPES

The users targeted for my redesign are users who use a vehicle with a traditional physical stereo system. My users include both men and women who are in the age range of 25 - 45. The users use their cars regularly for commuting and also use the stereo system to listen to music, radio,

audiobooks during their commute. They are reasonably tech literate and they use the car stereo controls every time they use the car. This answers the who are the users part of the data inventory.

2 NEEDFINDING PLAN 1

The first needfinding plan will be to conduct *naturalistic observation*.

2.1 What will be observed

I will observe the user's interaction with their stereo systems under various contexts. Like how often do they interact with the stereo system in their car. Do they know what they want when they are browsing through the stereo or are they randomly switching stations. How long does it take to fulfill a task that they have a clear idea of. How differently do they interact with the stereo when they are temporarily stopped (like at a red light) , when they are permanently stopped (at a parking lot) and finally while driving. I will also observe how the other passengers control the music system and their ease of access with varying contexts. I will also try to observe users as they listen to audio as they go about their day, how they interact with music when they are in the car and when they are outside to find the familiarities and differences in the interaction. This activity will help answer the contexts of the tasks and the user goals and needs which are part of the data inventory.

2.2 Where

This can be done by going on Uber Rides, Lyft Rides, Driving with Friends, The Shuttle I take to work where the drivers are constantly listening to music or the radio when they are driving. I will also observe taxi stands and stop signals to see how the drivers interact with the stereo system when they are stopped or stopping temporarily. This answer the Where part of the Data Inventory.

2.3 When

For the traffic stops and taxi stands, I would go there during times of peak occupancy that is between 9am - 10am in the morning and 6pm to 7pm in the evening. For Uber rides and travel use cases they can be monitored any time I travel and I can ask them to perform “think out loud” exercises while interacting with the stereo system to understand their thought process when they are interacting with the stereo. For the work use case, I think I would gather notes from observing the shuttle driver on the commute to work in the morning and evening and co-passengers interact with the stereo system.

2.4 What data will be gathered

I will measure the following as quantitative data. Firstly I will gather the time taken for a successful interaction with the stereo station , a successful search will be measured from the time the action is initiated to the time the user finishes performing the search.

Secondly I would measure the rate of error while interacting with the stereo. It could be trying to adjust the settings while wearing gloves, the errors captured by the voice assistants or accidental mode changes. The errors will be measured per 10 searches and multiple errors in the same search will be counted as '2' and a single error will be given the value '1' no error as '0'.

The qualitative data that I will gather will be based on the following. Firstly I will gather *how often* they interact with their car stereos. Secondly I will gather *how* they interact with their stereos, if they use buttons, voice assistants, gestures.

Thirdly I will gather *where* they interact with the stereos, are they switching between radio stations, their own playlists, have they connected their phones to the stereo and playing their songs

This will help in gathering the tasks and subtasks for the data inventory.

2.5 Biases

The biases that I will come across is confirmation bias. When performing naturalistic observation. This can be combated by specifically looking at signs that I'm wrong. I include the number of times they get it when finding the error rate. I may also run into recall bias when performing think out loud exercises with the users. This can be combated by asking users why they performed a task after the task was done instead of think-out-loud exercises for some users. This would help validate the data gathered from the think out loud exercises.

3 NEEDFINDING PLAN 2

The second needfinding plan will be based on *surveys*.

3.1 What will be asked in the survey

The below questions will be asked in the survey, these questions are designed to check if the users are facing an issue with the search in the first place to prevent confirmation bias. There are no leading questions and care has been taken to limit unconscious bias.

On a scale of 1 - 5 (with 1 being the lowest and 5 being the highest) how would you rate your ability to learn new interfaces quickly?

1. 2. 3. 4. 5.

On a scale of 1 - 5 how satisfied are you with the functionality of your car stereo in general?

1. Highly Dissatisfied 2. Dissatisfied 3. Neutral 4. Satisfied 5. Highly Satisfied

In what all modes do you use your car stereo ?

1. FM Radio 2. AM Radio 3. AUX 4. Bluetooth Pairing 5. Other(Please Specify)

From which devices do you pair your Bluetooth to your car Stereo ?

1. iPhone 2. Android Phone 3. Other Smartphones 4. Smart Watch 5. Other(Please Specify)

How often do you think you change or interact with the car stereo system in a single drive?

1. 0-1 times 2. 2- 4 times 3. 5-8 times 4. More than 9 times

Do you set presets to radio stations in your car?.

1. Yes 2. No

How likely are you to use voice assistants while interacting with your car stereo?

1. Extremely Unlikely 2. Unlikely 3. Occasionally 4. Likely 5. Extremely Likely

What is your primary mode when you use your stereo system?.

1. FM Radio 2. AM Radio 3. AUX 4. Bluetooth Pairing 5. CD 6. Cassettes 7. USB 8.Other(Please Specify)

Has the current stereo system interface in your car become invisible to you? (You can search for the functionality that you do not use and set them without fidgeting with the interface)

1. Fully Invisible 2. Mostly Invisible 3. Neutral 4. Sometimes Visible

   5. Fully Visible

How often do you switch between stations on the Radio when driving ?

1. 0-1 times 2. 2- 4 times 3. 5-8 times 4. More than 9 times

Is there anything about the stereo functionality in your car that you do not find useful?(Text Answers)

3.2 Who will you send the survey to?

The surveys will be sent out to daily users of users of cars that do not use a touch screen interface. So cars that were built till the late 2013's. I have a dozen friends that drive cars like this and I would primarily survey them along with the people I can find in this class.

3.3 Connection with the Data Inventory

The first two questions attempt to answer who the users are and where they are. Questions 3&4 attempts to understand the contexts of the tasks and the user needs. Questions 5 -7 tries to find the user goals and the task associated with it. Question 8-9 tries to understand the subtasks of the users.

3.4 Biases

The potential biases that can occur from this survey is that of observer bias, To combat this bias I had my questions reviewed by another neutral participant from the class. The second potential bias that would have occurred is that of Voluntary response bias, I tried to limit this bias by limiting the length of the survey and confirming the conclusions by the first needfinding.

4 DATA INVENTORY

After performing the naturalistic observation, administering a survey and analysing a competing interface. The study has sufficient data to answer the below questions.

Who are the Users? :

From the survey the users are car owners who utilise a traditional car stereo system. They are between the age groups of 25 - 65

Where are the Users?:

The users are passengers of Vehicles and drivers of vehicles which are retrofitted with these stereo interfaces. These users are in the cars when using the interfaces.

What is the context of the task?:

From the survey and naturalistic observation the context of the task revolves around driving. When interacting with the stereo, the users are driving a vehicle. From naturalistic observations it was found that most drivers interact with the stereo while driving the car. So the interaction with the stereo is almost always in the backdrop of the secondary task of driving.

What are their goals?:

From the data gathered from the naturalistic observation the goal of the user is to listen to music while driving and interact with their phones indirectly.

What do they need?:

The users require a method by which they are able to shift between the modes of the interface easily. They need an interface with the ports facing up to prevent wires getting tangled. They also require an interface which they are able to manipulate with one hand when driving a 100 on a freeway.

What are their tasks?:

Physically the task is to connect the stereo to the radio, phone and playing music. Cognitively the task is too detach from the primary task of driving and perform the secondary task of manipulating the stereo to fit their current needs.

What are their subtasks?:

Based on my naturalistic observation. I believe the subtasks are to divert attention from driving, change modes between FM, Aux and Phone. Perform the settings changes and continue performing the primary task of driving.

5 DEFINING REQUIREMENTS

The initial needfinding performed is based on the process of naturalistic observation and needfinding surveys. From these observations we've developed a focal point to build on. With 75% of the users surveyed stating that they were unhappy with their stereo interfaces. According to the user survey an average user interacted with the stereo 5-8 times in a single session. This number was upwards of 10 from naturalistic observation performed. Each session would last 9 - 10 seconds. The final interface would decrease the number of interactions performed and the time spent on the interface should decrease to half. The interface will also not contain any extra hardware and the identifier for success is how quickly an interaction is performed and the decrease in the number of interactions from a session.

6 HEURISTIC EVALUATION

Figure 2—Stereo Interface to be evaluated.

The above interface shown is the car stereo that I currently use. It has all the features of a modern stereo. It has bluetooth connectivity to connect to my Phone. It has FM/AM Radio, AUX Cables and USB compatibility. When connected to my phone the combination provides the same amount of functionality of a centre console found in the latest cars but the poorly designed interface makes it really difficult to operate.

WHAT WORKS WELL?

The best part of this stereo interface is that the equaliser. The Bass and Treble functionality can be easily manipulated dynamically for the best effect mid song allowing one to customise the sound easily according to the context of the music. The volume controls work well. Turning the knob is a really intuitive way to control the volume. The mode interchange works well as it is easy to switch between the different modes in this stereo. The remote allows other passengers other than the driver to use the stereo functionality easily with minimal disruption to the driver.

WHAT MAKES IT WORK WELL?

The equaliser functionality works well because it's **discoverable** due to the dedicated knobs on the stereo dedicated to Bass and Treble. The **Feedback** from the equaliser is immediate and enables the user to adjust those settings better. The volume knob works really well due to the **Mapping** of the knob to the volume. Turning the knob allows one to adjust the volume and speed of turning the knob. The Mode interchange works really well because of its placement and the **Signifier** indicating its functionality and the immediate feedback that is visible on the tiny LCD screen. The remote works well as it **removes the physical constraint** of interacting

with the stereo using the buttons, the functionality is also **consistent** across the stereo and the remote. Buttons labeled the same perform the same functionality.

WHAT DOESN'T WORK WELL?

The stereo does not have a dedicated mute button on the stereo. The buttons that are used to perform play, next, rewind are marked with the Scan, Vol+, Vol- buttons that perform differently under different contexts. The presets are not accessible from the stereo but only from the remote making the presets rarely used. The Bluetooth functionality is really complicated and the pairing procedure is not secure. I accept a call when my phone is connected to the stereo using the stereo. The lighting is really unintuitive, it lights up the body of the stereo instead of the writings present in the stereo. The angle of the AUX port is really awkward. A lot of the time, the AUX cable is accidentally pulled when I am working the gear knobs.

WHY DOESN'T IT WORK WELL?

The Mute button is present in the remote and I can mute the stereo by turning it off but the reason that this doesn't work well is due to the lack of **discoverability** of this functionality. The buttons that are double labelled, get their functionalities mixed up due to faulty **Mapping.** Under a particular context like a mode, my mental model expects the buttons to behave as controls but it ends up working as functionality buttons. The Preset for radio stations does not work well due to the **physical constraint** of the remote. It can get easily misplaced and having an additional peripheral to control the preset defeats the purpose of the preset. The Bluetooth functionality does not work well as the **Structure** of the functionality and how it is paired is unintuitive and does not make use of a pairing code. The lighting does not work as it does not illuminate the text and rather the body. It fails to act as a **signifier**. The AUX port does not work well because of the awkward angle of its position. It is present in the center of the console rather than the sides. This also has to do with the **Physical constraints** of the port being in an unintuitive location.

7 INTERFACE REDESIGN

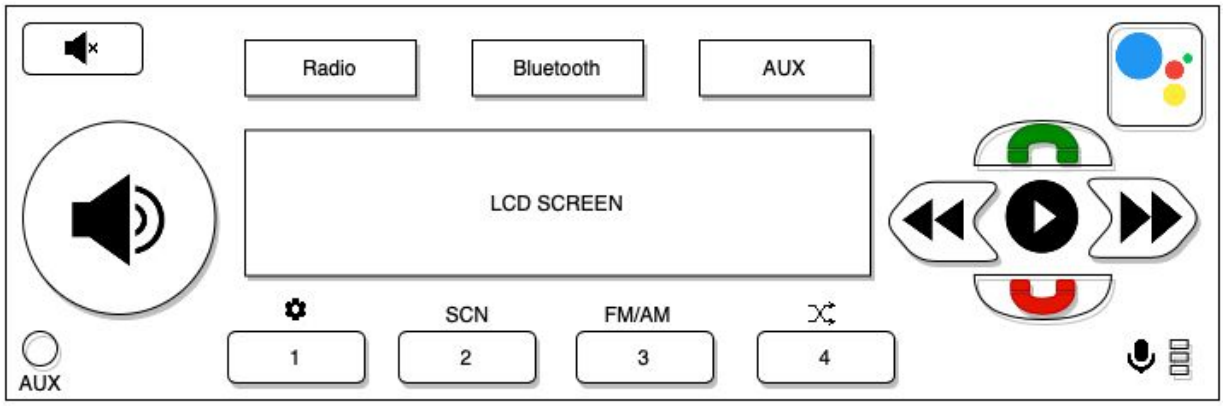

Figure 3— The redesigned car stereo interface

This is the redesigned interface for a car stereo system. The modes are explicitly defined. Based on the needfinding the 3 most used modes are Radio, Bluetooth pairing and AUX. To set a particular mode press that button and the chosen mode lights up to a red color. Each mode has a volume preset along with the mode by default. So listening to your phone at 20 and transitioning to radio, the volume of the radio will not be 20 but the initial volume. On selecting the mode, the buttons which are available to that mode lights up and is accessible and the buttons that aren't lit up are disabled.

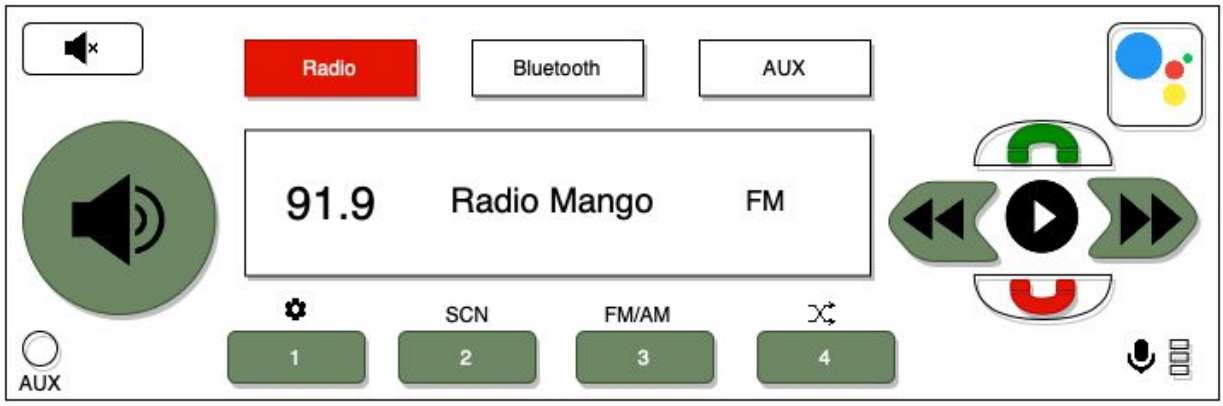

Figure 4— The redesigned car stereo interface in Radio Mode

Selecting a mode, the button lights up in red to let the user know what mode the stereo is in. When in Radio Mode the buttons labeled '1', '2','3','4' act as presets. On pressing 2 for 3s or more a scan is initiated. After a station is landed on, pressing '1' if no preset exists, the frequency is set at '1'. To delete a preset, press '1' & the call decline button together. Volume can be adjusted by turning the volume knob. Pressing the '3' button for 3s or more allows you to

change between AM/FM frequencies. >> button is used to go to the next frequency when scanning. << is used to go to the previous frequency when scanning. ’

Figure 5— The redesigned car stereo interface in Bluetooth Mode

For the Bluetooth Mode, to pair the system with the phone you initiate the pairing from your phone and enter a code displayed on the LCD. ‘4’ initiates shuffle. The voice assistant button invokes the voice assistant. The green button is used to pick up calls, and the Red button hangs up calls. The << button plays previous songs, but if the content was muffled due to notification, tapping the << button twice rewinds by 15s. More than one phone can be connected at the same time.

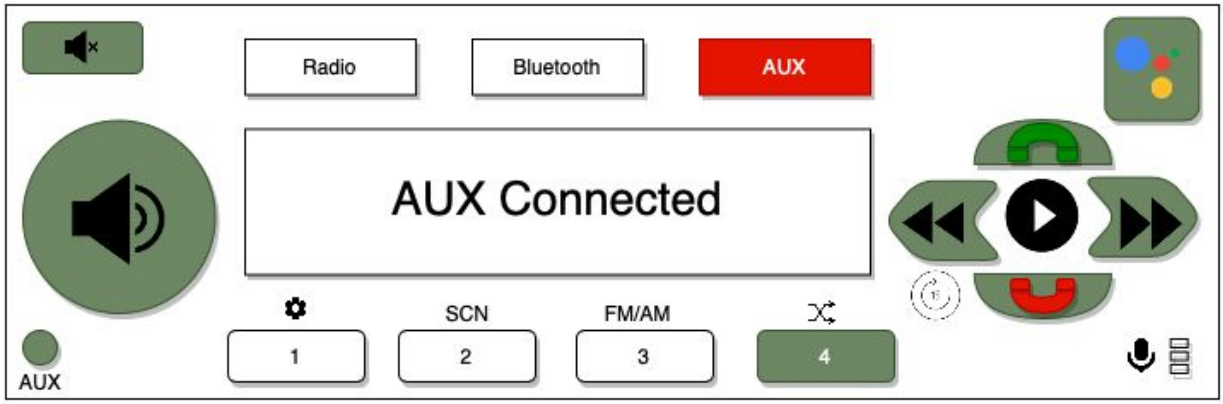

Figure 6— The redesigned car stereo interface in AUX Mode

The AUX Mode works similarly to the Bluetooth mode. But the rewind 15s functionality wouldn't be available.

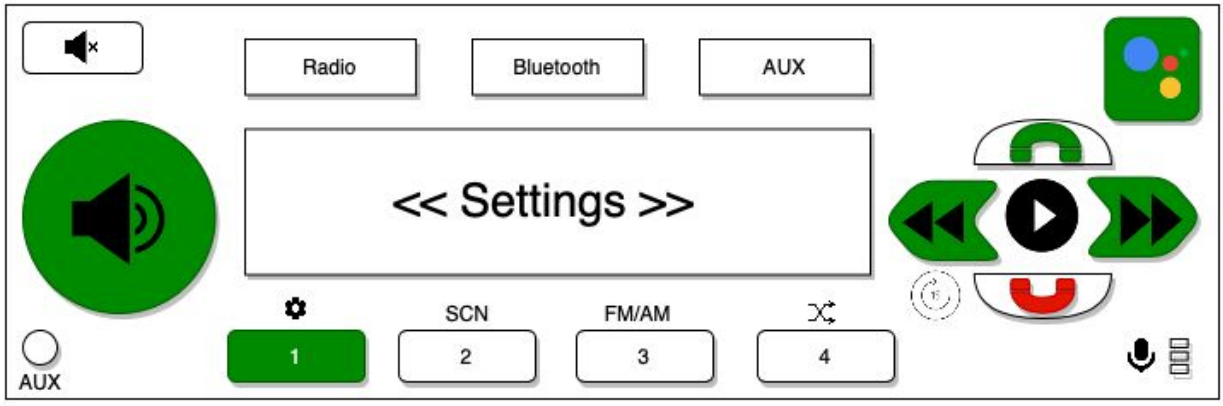

Figure 7 — The redesigned car stereo interface in Settings Mode

To enter into settings, none of the modes have to be selected and then select '1'. To enter into the settings menu. >> and << buttons are used to navigate the different settings. The play button is used for an OK button. The current value is displayed along with the property. The property can be increased on decreased using the volume property.

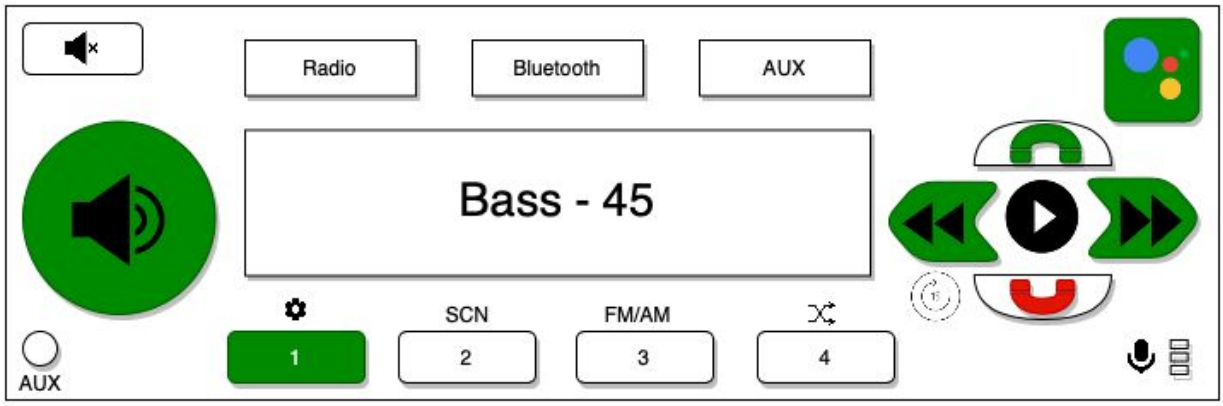

Figure 8— The redesigned car stereo interface when changing Audio settings

Modifying the equaliser setting is a higher level feature that is not used all the time and is only used by a niche audience. To get further control over the equaliser, the remote can be used. The remote is a mobile application instead of a physical remote. The interface for the mobile app is given below. On the top the slider can change the mode. The icon in the middle is the current mode. Selecting the equaliser icon brings you to the equaliser menu where one can set the equaliser settings and click the X on top to exit the equaliser menu.

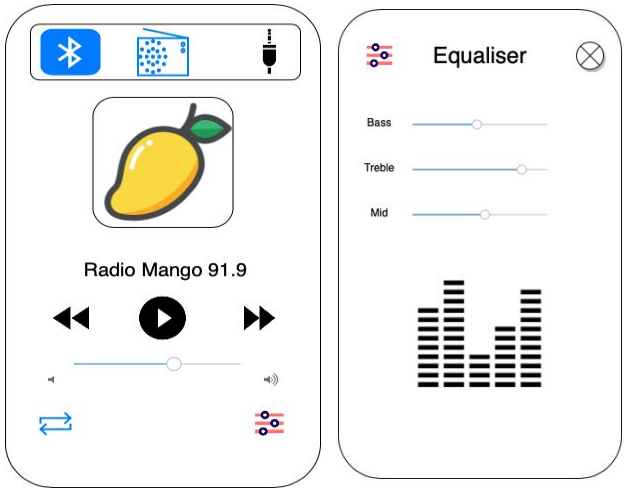

Figure 9— The redesigned car stereo interface Remote Application

8 INTERFACE JUSTIFICATION

The redesigned interface captures the best of the interfaces and redesigned the parts of the interface that do not work as well. The design principles that are followed in the redesign are

8.1 DISCOVERABILITY

The original interface had some elements that were discoverable like the bass, treble, and the Volume. To make the interfaces more discoverable, the modes have their own explicit buttons. I've retained the Volume knob from the original interface, and moved the bass and treble to the settings.. I've added 2 buttons on top of the 'Play' button to make the phone functionality more discoverable. I've moved some functionality from the remote to the stereo to make them more discoverable like the mute buttons and the radio presets, along with the shuffle, next, previous and play buttons. Additionally, I've added an explicit button to make Voice Assistants more discoverable which was not present in the original interface but was found out as part of the needfinding exercises.

8.2 FEEDBACK

The original interface provided immediate feedback for some of the settings like Volume, Bass, Treble and Mode Change. This has been retained and refined. The feedback was usually provided by changes in the sound and changes in the value provided through the display. The Volume, Bass and Treble provide feedback in the same manner. The mode change because of its new more discoverable interface provides an additional layer of feedback by lighting up the

selected mode and dimming the other modes. This provides the user a more explicit feedback than that was provided in the previous interfaces.

8.3 CONSTRAINTS

The original interface used constraints to varying degrees of success. Due to the limited space on the physical stereo a lot of the functionality was off-loaded to the attached physical remote which provided a physical constraint in operating the stereo. This principle has been extended in the redesign. For every mode in the stereo an explicit set of buttons are lit up as shown in the redesign section. The buttons that are not useful in the mode are deactivated to prevent accidental mode changes. This restricts the user to a set of buttons that can be used in that particular mode. The physical constraint of a remote is also removed in the interface as the physical remote is replaced by an application which connects to the phone using Bluetooth. The physical location of the AUX port which in the original interface took a more central position whereas in the redesigned interface the port is moved to the side to prevent it from interfering with the other controls.

8.4 MAPPING

The original interface uses the Volume knob to map the volume, this has been retained in the redesigned interface but other than this, the mappings in the original interfaces were abysmal as the buttons were double labelled. These mappings are removed in the redesign to include a more simple set of mappings. Most buttons perform only a single set functionality and lesser used features are offloaded to the Application where they can be mapped better by a slider. The preset buttons provide more than one mapping but their functionality is independent of each other in different modes making their mapping intact across modes.

8.5 CONSISTENCY

The original interface provided a consistent interface across the remote and the physical stereo itself. This consistency has been retained within the redesigned interface. The Volume knob operates the same way, there are physical buttons for modes. The same set of labels are used across the interface for ‘forward’, ‘play’, ‘rewind’, ‘volume’, ‘mute’ which are used universally. The redesigned application also uses these symbols. The Assistant button uses the symbol for Google Assistant which is used across interfaces.

8.6 AFFORDANCES

The original interface did not provide good affordances. The lighting blocked the affordances and none of the buttons said what they did. A lot of the core functionality was off-loaded to the remote where it contained signifiers for the functionality but generally most affordances were buried under the unintuitive interface or not present at all despite having the hardware to perform it. I've added the phone functionality in the redesigned interface and provided two buttons as signifiers to this affordance. This will enable users to pick up and perform calls. Additionally I've added an explicit button to evoke the assistant which is a signifier. The buttons which are available in a mode light up and the ones that aren't, do not.

9 EVALUATION PLAN EMPIRICAL EVALUATION

Since the interface is improving existing functionality rather than adding new functionality, I will be performing Empirical Evaluation on the below redesigned interface.

Figure 10 - Wireframe of the redesigned prototype

The goal of this evaluation is to identify if the additional features and redesign on the interface introduced in the redesign improves the time taken for a user to adjust a particular setting in a car stereo. The comparison in this situation will be with the existing interface which was explained in Check-in 2.

The comparison metric would be the time it takes to change modes in the stereo, set presets for the radio, adjust the volume, accept and decline a call and mute the stereo. From the needfinding exercises performed, these were the most commonly performed tasks on the stereo. Another metric that will be measured is how often a user interacts with the stereo with the redesigned interface compared to the original interface.

The *Null hypothesis* from this evaluation is that the average time taken to perform a change in the redesigned stereo is the same as the original stereo and the average number of interactions

with the interface remains the same. Hence the users do not find the redesigned interface useful. The *Alternative hypothesis* of this evaluation is that there is a significant decrease in the average time taken to perform a change is the redesigned interface (above a 5% margin of error) or there is a decrease in the average number of interactions with the stereo system (above a 5% margin of error) and the users find the interface useful.

The Experimental Method that is to be used ideally consists of a random assignment of subjects in Within-subject designs with half the group getting the original interface first and the latter receiving the redesign. The data generated would be captured by software logs to test the user numbers objectively. Unfortunately, this is not possible without extensive programming, so this solution would be administered without recreating the interface.

In the first treatment, the users while driving or when performing their normal routines in the car instead of the stereo they interact with a dummy remote placed on a stand at an intuitive location. Like the stereo the remote has an explicit button for mute, explicit audio controls, and preset buttons that can be set to radio stations. The top 3 buttons would act as the different mode buttons . This would simulate the ease of access as mentioned in the redesign. The call functionality would be recreated using RPT and US/D buttons acting as the call accept and decline buttons. The functionality would be recreated using a working remote, recreating a Wizard of Oz prototype where the evoked functionality would be recreated by the tester.

The second treatment would be where the participants will have a normal session where they drive with the normal existing interface. The time would be captured manually in both occurrences.

This approach has a significant lurking variable in that the icons do not match the responses as intended (RPT and US/D buttons being used as call accept and decline). However, we assume that with the proper mapping the responses would be more efficient. Another lurking data would be that the differences captured in the redesign would be rounded off to the nearest second and it would not be able to provide enough accuracy to disprove the null hypothesis.

A third lurking variable would be the changing user preferences from time to time, for example at the time of using the traditional interface the shuffle functionality on the users phone might pop up songs they like more, the radio may play not air the ad they find annoying, or they would be less likely to be themselves in a controlled treatment environment and hence would use their phones or search less likely or more than if they were not being monitored.

10 EVALUATION EXECUTION

As detailed in the section above, the goal of this evaluation is to identify whether or not the redesigned interface with dedicated mode interchange buttons where the mode buttons are highlighted based on the mode selected. The experimental groups used a dummy remote to simulate the functionality of the redesigned interface. The functionality was replicated by performing a Wizard of Oz prototype behind the scene. Users were placed in the driving seat of the car with the dummy remote in an easy to access area. Execution of this experiment was performed with 7 participants, each doing both the treatments To prevent the sequence of performing either the control or experimental first having an effect on the experimental results, the participants were split in half where each group performed either feature first. Administering the experiment led to a few hiccups and the process was adjusted to compensate for the issues.

The first issue was the timestamp accuracy. The time noted for the actions performed in the treatments was measured to the nearest second. This is a problem as the granularity may not be enough to separate the two actions performed under different treatments. Next, since the treatments were performed both in a stationary and a moving car, there were other variables in play like the traffic, the number of people on the road, the skill of the driver which made the experience, not as uniform between drivers. To adjust for this, a majority of the experiments were conducted on private roads that had no traffic when the experiments were conducted to adjust for the lurking variables. Administering the experiment utilizes seven individuals who are reasonably proficient in driving, all of them have been driving for at least 5 years and use the stereo when driving. The experiment contained a small number of participants which is a cause for the disparity. The raw experimental data can be found in the indices.

To summarize the results, the ‘t’ statistic and p-value is calculated for each approach in addition to the mean median and the standard deviation. Supporting the alternate hypothesis, it's found that the t-statistical value is large at 9.357 with a significantly small p-value of 1.337*10^-11 These testing methods will not be completely accurate owing to the skewed nature of both distributions. From the testing performed though, there is enough evidence to reject the null hypothesis. Investigating deeper, the experiment finds that the new feature on average reduces the response time of the stereo by over 14 seconds from 7:52 minutes to 8:06 minutes between treatments.

Following a summary of the overall results, each person is also analyzed to determine if there was an improvement in speed individually. Each participant has improved their response time when using the new interface. Unfortunately, the conclusions must consider the limited

sampling size per person, and all the users who performed the treatments were experienced drivers.

While the experiment and the analysis were relatively successful, numerous changes could be implemented for improvement, The users could be more in size and of varying differences in proficiency, all the users who performed this test were familiar with the existing interface peripherally. The experiments could also be conducted in a more formal environment with a redesigned interface and proper mapping to the metadata with millisecond tracing performed by computerized logging, The experiment would be more successful.

11 APPENDICES

11.1: Naturalistic Observation results can be found in the below link:

https://drive.google.com/file/d/1HL9KUv833LR7_I782o0o5dYxvVZtAraP/view?usp=sharing

11.2: Survey responses.

https://docs.google.com/document/d/1Ve6Hbz_jcTnHi9MIqJ2ji_SX4opT2P2Mtp3muwqAzDo/edit?usp=sharing

11.3 Empirical Evaluation Results

https://docs.google.com/spreadsheets/d/1oaWWFXPAiQRb_0yjLwcCHmRZgGYTK7HFuET6IMC11hA/edit?usp=sharing