Christopher Di Giulio

M.S. Human Systems Engineering Portfolio

Advisor: Nancy Cooke
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Christopher Di Giulio

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Education

Arizona State University – Mesa, AZ

M.S. Human Systems Engineering May 2020

- *Honors*: Summa Cum Laude
- *Cumulative GPA*: 4.00

B.S. Human Systems Engineering May 2019

- *Honors*: Summa Cum Laude, selected by faculty as the Outstanding Graduate in Human Systems Engineering
- *Cumulative GPA*: 4.00

Professional Experience

Arizona State University Human-Robot Interaction Lab – Mesa, AZ June 2019 – May 2020

Graduate Research Assistant

- Conducted research to identify optimal communication methods between human operators and artificial intelligence for urban search and rescue operations
- Operated simulated 3D environment to interact with 60 research participants
- Trained 4 coworkers in 3D environment navigation and data analysis
- Collaborated with team of experimenters to collect, code, and analyze data measured from participants
- Developed a consensus codebook with team members to accurately map qualitative data to a quantitative metric in order to establish an objective measurement protocol

Academic Projects

System Usability Testing for Hyundai – ASU Spring 2020

- Collaborated with teammates to conduct usability test of official Hyundai digital center console prototype
- Diagnosed usability problems by recruiting participants to use basic driving simulator while operating console prototype
- Performed heuristic evaluation and task analyses to identify key issues and their severity levels
- Interviewed end-users to better understand their expectations and preferences while using interface
- Created journey maps, wireframes and end-user personas to guide design
- Designed and prototyped feature improvements to mitigate divided attention risk while maximizing user satisfaction and efficiency while driving
- Standardized user interfaces to ensure consistent style
- Presented design ideas and revisions to peers, faculty and a Hyundai human factors professional

Implications for Hygienic Design in Public Facilities – ASU Spring 2019

- Conducted study to identify optimal design for public facilities to minimize pathogenic transmission for users
- Reviewed existing literature regarding prevalence of safety concerns and various bacteria present in public areas
- Collected field data and created user flow maps through site visits to 10 locations
- Analyzed field data to identify opportunities to improve accessibility and hygiene at high-traffic public sites

Technical Skills

- **Data Analysis and Statistics:** SQL, SPSS, R
- **Design and Applications:** Figma, GNU Image Manipulation
- **Other:** Microsoft Access, Excel, PowerPoint, Word

Additional Accomplishments & Interests

- 1st Degree Black Belt in Freestyle Karate
- Developed digital merchandise for video game developer
- Proficient in building custom desktop computers for various computational requirements

Overview

This portfolio comprises three of my works I have completed throughout my time as a graduate student at Arizona State University. These projects briefly demonstrate the broad application of skills I have acquired during my time in various classes while showcasing how I have honed my ability to approach diverse tasks or problems in creative and effective ways.

The first accomplishment I have presented here in this portfolio comprises a literature review in regards to the phenomenon referred to as “auditory preemption.” The review examines what the phenomenon is, why it is important, and what its implications are for varying engineering and design standpoints, especially when considering factors such as safety and efficiency. Additionally, this review represents how I can ask important questions that focus on critical significances in research and design, and reveals the importance of identifying and analyzing the work of others, as well as the questions that they have asked and answered.

Concerning my abilities to evaluate and interpret designs, my second accomplishment exhibits an analysis of a Hyundai center console prototype that our class was granted access to. My team of eight other individuals and I were tasked with scrutinizing the prototypical digital center console to be used in Hyundai’s vehicles. Together, we gauged and evaluated principles such as ease of use, efficiency, and safety when utilizing the technology behind the wheel of an electronic driving simulator. This project substantially exercised my ability to work with real-world products that were in need of revision and testing. Moreover, this project allowed me to practice effective collaboration between team members who assisted each other in the process of assessing a multifaceted product.

Lastly, my third accomplishment involves the process of data visualization through the use of RStudio. This project demanded the comprehension of the program's syntax, and how to correctly interpret the meaning and significance of the statistical aspects regarding the data in question. The data involved is from a study that took place in ASU's polytechnic lab, which investigated the methods in which humans work with artificial intelligence to accomplish tasks that are of a high stress nature. This project not only showcases my ability to work with RStudio, but delineates my capability in understanding the somewhat ubiquitous process of implementing and deciphering the syntactic lines of code used in various backend systems.

Accomplishments

Literature Review: Auditory Preemption

This paper presents an in-depth literature review regarding the topic of auditory preemption. While investigating the phenomenon, questions such as "To what degree does the preemption of audition hinder the performance of other tasks in simultaneity?" and "Are there any methods in terms of design to either circumvent or perhaps mitigate the effects of auditory preemption?" The review encompasses the major overhanging implications in terms of how designs can improve based on the findings of the phenomenon.

Significance

The investigation of this topic is incredibly important as complex technology quickly becomes increasingly present in everyday life. It is critical to understand how human perceptual systems function, and furthermore, recognizing their shortcomings--especially when taking safety into consideration in situations such as using technology while operating a motor vehicle, as this setting is inherently dangerous with distractions.

Related Materials

The full literature review is located in Appendix A.

Summary

When designing any piece of technology or equipment that is supposed to be used by humans, the human should be at the epicenter--cognitively, physically, anatomically, and physiologically. In order to embody all principles of human factors, it is vital to investigate the perceptual systems that humans possess. These perceptual systems include the five commonly known senses of touch (somatosensory), taste (gustation), smell (olfaction), sight (vision), and hearing (audition). Senses such as vision and audition are most commonly invoked in engineering designs, but there are a few more, lesser known systems that humans have at their disposal to collect information from the environment. These include proprioception, which involves the human's awareness of bodily position and movement, either in supplementation or absence of other senses that provide spatial or positional information. The vestibular system is another sense that humans have to supplement spatial orientation information. This sense is located within the inner ear anatomy, and assists humans with balance. The vestibular system can, in part, contribute to motion sickness susceptibility, wherein if a person's perceived sensations are not consistent with each other (such as sitting in a still seat with moving visual stimuli), then symptoms such as nausea, dizziness, or headaches can occur.

With respect to auditory preemption, when individuals are tasked with attending to a visual stimulus, any auditory stimulus will almost certainly interrupt a person's ongoing task, noticeably decreasing performance on the visual task (Wickens & Colcombe, 2007). This is partially due to the omnidirectional nature of sound--that is, no matter the spatial orientation of a person's head or body, sound can generally be perceived rather easily.

References

Costa, R., & Friedrich, E. (2012). Inhibition, interference, and conflict in task switching. *Psychonomic Bulletin & Review, 19*(6), 1193-1201.

Jeon, M., Gable, T. M., Davison, B. K., Nees, M. A., Wilson, J., & Walker, B. N. (2015). Menu Navigation With In-Vehicle Technologies: Auditory Menu Cues Improve Dual Task Performance, Preference, and Workload. *International Journal of Human-Computer Interaction*, *31*(1), 1–16.

Lancaster, J., & Casali, J. (2008). Investigating Pilot Performance Using Mixed-Modality Simulated Data Link. *Human Factors: The Journal of Human Factors and Ergonomic Society, 50*(2), 183-193.

Lees, M., Cosman, J., Lee, J., Vecera, S., Dawson, J., & Rizzo, M. (2012). Cross-modal warnings for orienting attention in older drivers with and without attention impairments. *Applied Ergonomics, 43*(4), 768-776.

Lu, S., Wickens, C., Prinet, J., Hutchins, S., Sarter, N., & Sebok, A. (2013). Supporting Interruption Management and Multimodal Interface Design: Three Meta-Analyses of Task Performance as a Function of Interrupting Task Modality. *Human Factors: The Journal of Human Factors and Ergonomics Society, 55*(4), 697-724.

Smith, C., Clegg, B., Heggestad, E., & Hopp-Levine, P. (2009). Interruption management: A comparison of auditory and tactile cues for both alerting and orienting. *International Journal of Human - Computer Studies, 67*(9), 777-786.

Wickens, C. D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomics Science*, *3*, 159–177.

Wickens, C., & Colcombe, A. (2007). Dual-Task Performance Consequences of Imperfect Alerting Associated With a Cockpit Display of Traffic Information. *Human Factors: The Journal of Human Factors and Ergonomic Society, 49*(5), 839-850.

Hyundai Prototype Infotainment System Evaluation

This project entailed working alongside a team of eight other people in the process of evaluating a prototypical center console system's usability, and its implications for safety and ease of use while simulating being on the road (by utilizing a digital driving simulator). My team members and I executed multiple tests with the center console prototype in order to firstly understand how the system functions, and, consequently, learn how impactful utilizing the center console in its current state would impact the primary task of driving, due to the fact that the technology will be used by customers while they operate the vehicle.

Significance

Conducting tests such as heuristic evaluations, task analyses, creating journey maps, and developing wireframes or preliminary designs for large, complex mechanisms of engineering (such as cars, computers, websites, etcetera) is pivotal in identifying what works and what does not work. Merely ensuring that technology functions the way that it was developed on the backend is foolishly insufficient. Of course it is important to make sure technology functions the way it is supposed to, but the technology must be tested in the conditions that it will be used for the end-user.

Related Materials

Appendix B contains the final presentation that my team and I showed to both the course instructor and a Hyundai human factors employee that granted us access to work with the prototype.

Summary

Just like cell phones did within the past two decades, vehicle center consoles also have started to integrate comprehensive computing technologies that can perform a wide variety of complex processes. This includes making phone calls, utilizing navigation software, pairing Bluetooth devices, listening to music, controlling the climate and temperature of the vehicle, using cameras on the exterior of the vehicle, and more. Essentially, vehicle technology has evolved to the point in which virtually every brand of vehicle consists of a digital center console with its own unique operating system. This vast sea of differentiating user interfaces, gestures, and gaps in usability make for a confusing world of learning how to use so many divergent styles of user interfaces.

Nielsen and Molich (1990) outline four basic ways to evaluate a user interface: formally, by using some analysis technique, automatically using computer software, empirically by utilizing experiments with variable testing, and heuristically, by simply looking at the design's interface and criticizing or passing judgment as per one's opinion. Heuristic evaluations are useful in that they are cheap, the usability method is easy and people can be easily motivated to participate, advanced planning is not required, and heuristic evaluations can be used early in the design process.

In a similar manner, Richardson (2015) notes how another useful evaluative tool, a journey map, can be broken down into 4 categories: 1) Actions, which involves the actions the consumer takes when moving themselves to the next stage. 2) Motivations, which entails the reasoning behind why the customer is motivated to reach each proximate stage. This category also involves the consumer's emotions and how they're feeling regarding their experience. 3) Questions, which regard the uncertainties, jargon, and things that the customer may not understand. This category comprises issues or problems that the customer is experiencing that are preventing them from moving on to the next stage. 4) Barriers--these involve the structural, process, cost, implementation, or any other possible obstacles that prevent the user or customer from moving on to the next stage in the process.

Although there are numerous distinct user interfaces for disparate brands of vehicles, there are several universal features that have become commonplace within user interfaces. Examples of this include the hamburger menu, the back button, home button, and so on. Whether these ubiquitous symbols and representative icons are necessary or effective is an argument of its own to be had, depending on the application. Nonetheless, carrying out these tests, creating preliminary designs, forming journey maps, and revising existing designs on the basis of usability tests should be considered integral and essential for ensuring a finalized, developed product that has been proven and worthy of operation and utilization by the intended end-user.

References

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* 249-256.

Richardson, A. (2015). Using Customer Journey Maps to Improve Customer Experience.

RStudio Data Visualization

Using existing data from an ASU study regarding human-robot interaction which I personally took part in collecting, verbal response data from the participating subjects were used to represent a measure for humans' trust in automation. Utilizing a series of questions that required participants' scale responses, whether they trusted--or lacked trust in--the automation in which they interacted with during the study session was determined (scale responses ranged from 1 to 7, low to high trust, respectively).

Significance

Collecting data is merely the first step in an extremely important process of analyzing a relationship between two or more variables, and then interpreting their relationship. Being able to understand the implications that statistical analyses provide can assist researchers in the process of massively improving a product's usability, how user-friendly an interface is, and to drastically improve error recovery time in the event that errors do occur.

As the complexity of technology increases in many applications, interactions and teaming between artificial intelligence and humans will have a greater prominence in various settings. For this research topic, I investigated the strength--or lack thereof--in trust that a human has in artificial intelligence (a robot). More specifically, the research question here revolves around the following: How confident in a robot teammate are human operators in a search and rescue application? The dataset that was used is based on a human-robot interaction study here at ASU, which looks at the interaction between human participants and another human who poses as a robot and works with the participant while controlling a character in the game Minecraft from another room. I utilized the post-test survey questions found in the collected data, in assisting hypothesis formulation as to why, based on their responses to the items found in the data, participants may have had strong or weak trust in what they were led to believe was artificial intelligence.

Related Materials

Appendix C contains the data visualization as well as the original data that was used for the visual representation.

Summary

Taking raw data, coding it into a statistically manipulative format, and then analyzing it is not quite the entire necessary operation for data processing. Perhaps the most important aspect of statistical analysis is providing ample visual representation that concisely displays the results for easy interpretation. If this step is not executed carefully, then there is little to be shown for the statistical work performed in regards to any study. Even though multiple data or variables can be shown in a single plot or visual representation of data, sometimes it can be beneficial to both the researchers as well as the audience--to clearly see a specific relationship.

One concept that holds this principle of ease-of-viewing closely is data-to-ink ratio. Data-to-ink ratio refers to the amount of noise that is presented in a graph or plot that the viewer must contend with. Increasing the data-to-ink ratio assists in visualizing or interpreting that data in a quicker, less effortful manner (Stengel, Calori, & Giannoudis, 2008). Conversely, decreasing the data-to-ink ratio results in more effortful data interpretation. This concept is incredibly important in order to facilitate easier data interpretation with minimal visual noise.

Each participant in the study was tasked with following along a robot (who was actually played by a human, unbeknownst to the participants) in a 3 dimensional world--created in the popular video game known as Minecraft--marking down the locations and statuses of victims (which were represented with different colored blocks. Each of the participants were given a map of the virtual office building's floor plan, which indicated the locations of all rooms and doors. However, because the study involved simulating an urban search and rescue situation, the floor plan was not necessarily the same. That is, some of the interior walls may have collapsed, and some of the doors and openings may have become blocked during the time the building was suffering damage. Participants were informed that the floor plan would not perfectly represent the building's accessibility, but they were not informed where, when, or in what way the building would show structural damage. Each participant was given the ability to communicate with the robot during the missions, wherein they could command the robot to pause, report status, or search rooms more than once. In some occurrences, there was visible frustration from participants, but ultimately, each participant accurately recorded at least 40% of the locations and statuses of victims and structural damage.

References

Stengel, D., Calori, G., & Giannoudis, P. (2008). Graphical data presentation. *Injury, 39*(6), 659-665.

Reflections

Reflections

When looking back at both my undergraduate and graduate experiences at ASU, the primary difference between these times for me was that in graduate school, very much of what was required was almost completely on my own shoulders. That is, instructors tended to allow my work and input to be more of my own as opposed to the somewhat more guided or "on rails" experience in undergraduate school. At first, this new challenge left me slightly uncomfortable. However, I quickly acclimated and began to appreciate this change. Not only was I able to choose how to uniquely approach solutions now, but I was also able to uniquely create my own questions, which led to additional questions that I had come up with on my own in a sort of chain reaction. The work that I had cut out for myself often sent me on a spiraling search for more information regarding attention, cognition, and user interfaces--as well as their implications for engineering design--because I became exponentially more interested in these topics I was tackling throughout my time in graduate school.

The projects that I have chosen to highlight within this portfolio show how I have evolved to think more critically than I did prior to my graduate school experience. By completing tasks such as literature reviews, comprehensive team-based usability evaluations, and working with statistical and data visualization software, not only has my knowledge base grown, but my ability to overcome complex problems that necessitate multifaceted approaches has broadened.

In addition to the challenges I have faced and surmounted during my time in graduate school, the opportunity to work as a graduate research assistant under the Human Systems Engineering lab was extraordinarily supplemental in my ability to learn new valuable skills. There were many times I used skills obtained from my graduate research assistant lab work to help solve problems in my coursework, such as conducting research, collecting data, or coding and organizing data. Likewise, there were plenty of instances in which I used skills I had attained from coursework or lectures that I applied toward lab work as a graduate research assistant. Ultimately, my experience as a graduate student greatly bolstered my capability as a critical thinker, greatly enhanced my judgment in problem solving, and encouraged my will to tackle new problems that I would have previously been unsure of how to approach.

Appendix A

Christopher Di Giulio

Auditory Preemption Literature Review

Introduction

The ability to be notified of some sort of an alert in the event of an emergency, or perhaps in less critical circumstances when something requires one's attention can be taken advantage of in terms of design principles. In some settings--like those that require less immediacy--the design can be centered around the visual modality, in that a blinking light or motion onset phenomenon can engage the attention of the user, wherein the user can be notified in a bottom-up fashion to attend to the task that must be handled.

In other settings--such as those that require immediate responses or those that can be considered emergencies--the auditory system is often invoked. This is because the human sense of audition is omnidirectional as well as preemptive. For example, in the event of a fire inside of a building where many people have congregated, the typically exhibited fire alarm is that of an extremely loud, repetitive noise, often so loud that it induces the threshold of pain for many people. The fact that the auditory sense in terms of alert salience can be both preemptive and omnidirectional can be seen as a double-edged sword. That is, a loud, clearly salient, and recurring noise can very effectively capture the attention of anyone who is within proximity, but this inherent preemption can also preclude other tasks that may need to be attended to.

Some pertinent questions can be raised in light of the phenomenon of auditory preemption, such as "To what degree does the preemption of audition hinder the performance of other tasks in simultaneity?" and "Are there any methods in terms of design to either circumvent or perhaps mitigate the effects of auditory preemption?"

Background

Because the nature of auditory preemption is inherently pertinent to circumstances in which another task interrupts an ongoing task, it is important to understand where and how these interrupting tasks temporally occur when switching between tasks.

A study by Costa and Friedrich (2012) examines whether task inhibition occurs at either the stimulus or response level. Additionally, the study looks at when those inhibitions occur during the process of task switching, and the implications and/or consequences of that inhibition. The purpose of the study was to examine if the inhibition of a task occurs at the presentation of a stimulus (e.g. a salient alarm or flashing light), or at the point in time in which the individual responds or reacts to said stimulus (stimulus level vs. response level).

The authors question if inhibition is a necessary process when disengaging from one task and engaging an interrupting one. The authors also state that inhibition may serve to decrease the amount of perceptual interference from any irrelevant or temporally unimportant features.

The experiment was run on E-Prime version 1.0 software, presented on an 18-inch monitor. 36 college-aged participants were recruited from undergraduate psychology courses. 21 female and 15 male. The experiment had three tasks, each consisting of two associated figures: red/green for the color task, horizontal/vertical lines for orientation, and a triangle or circle for shape. The task for the trial that was about to be presented was cued prior to the stimuli with the word “color,” “line,” or “shape.” Reaction times from the onset of the target stimulus to the press of the button were recorded, as well as the accuracy of participants’ button presses. Each target stimulus corresponded to one of the six total buttons on the response box, each response button at an equal distance away from a center finger rest pad. Participants were instructed to respond using their index finger of their preferred hand and to then return their finger to the rest pad after each response was made.

The participants completed ten experimental blocks of 50 trials each. Reaction times and accuracy were reported to each participant after each block to motivate them to respond as fast and accurately as possible. In about 33% of the trials, participants repeated the same task they had performed on the prior trial, while they switched to a new task in about 66% of the trials. Half of the task switches were backward inhibition (ABA tasks), while the other half of those performed switches were not (CBA tasks).

A 2x2 ANOVA was carried out on median reaction time data to measure effects of switch cost and preparation interval. Main effects were significant for task switch and cue-target interval (500 or 1000 ms before onset of target stimulus). The analysis showed faster reaction times for task repeats than for switches and for the longer cue-target interval (1000 ms) than for the short cue-target interval (500 ms). Furthermore, the analysis showed a significant interaction effect between task switch and cue-target interval, with a smaller switch cost at the long cue-target interval than at the short one. Additionally, a 2x2 ANOVA was conducted on the task switch trials, which showed a main effect of backward inhibition; longer reaction times were exhibited when the most recently disengaged task was reactivated. The main effect of cue-target interval was significant as well, showing faster reaction times for the long cue-target interval. Cue-target interval did not have a significant interaction effect with backward inhibition, however. The results ultimately suggest that proactive inhibition may be the source of the backward inhibition effect.

One possible confound in this study is the difference between male and female processing speed/ability in discerning directional orientation and spatial awareness versus discerning detail descriptions and objective memory, respectively. It would be particularly interesting to determine if such a factor may have confounded this experiment, considering both detail and directional orientation skills are required for the task.

This study shows how, in some cases, the ABA structure (ongoing task, interrupting task, original task) for task switching can generally be more inhibiting, or more difficult to carry out, than the CBA structure (switching to a new task each time) of task switching. The perfect answer to why this is not exactly clear, but it definitely has something to do with the latter being a new task each time, whereas the former is a double switch, that is, returning to the previous ongoing task after attending to a new interrupting task.

Wickens and Colcombe (2007) carried out a study that examined the shared responsibility between pilots and air traffic controllers regarding safe airspace separation. The study observed the performance of student pilots' tracking task while simultaneously monitoring air traffic conflicts with the aid of a cockpit display of traffic information (CDTI). Items that varied in the experiment were the threshold, modality, and level of alert. The results of the experiment showed that there was evidence of auditory preemption occurring when there were auditory alerts present in conjunction with visual tasks.

Results of the study revealed that the human's auditory system is prone to take priority and/or distract from preexisting tasks. As previously stated, this can be both good and bad, as alert salience must be high and readily noticeable in emergency situations, but continuous or continual auditory alerts can ultimately result in decreased performance for other tasks that, of course, utilize the auditory modality, or even other modalities like vision.

A study executed by Lees, et al. (2012) looked at older drivers, who are overrepresented in car accidents that are fatal on a per-mile basis. Those with useful field of view (UFOV) reductions--such as older drivers or elderly individuals whose sense of vision generally begins to degrade--propose a particular risk of accidents that is somewhat elevated that may be lowered with the presence of vehicle-based warnings.

In the experiment, 29 older drivers with UFOV impairments and 32 older drivers without impairments participated. Cues for each participant were presented in three different modalities: visual, auditory, and haptic. Sometimes cues would only be of one modality, and sometimes there was a combination of modalities. Results showed that the reaction times for both impaired drivers and unimpaired drivers were comparable between the various combinations of modalities used for in-vehicle alerts during the simulation. However, when redundant visual cues were paired with auditory cues, performance was actually undermined rather than enhanced. Such an outcome supports the idea that the delivery of auditory information, when already processing visual information, interrupts performance, hence the phenomenon of auditory preemption.

Through a study conducted by Smith, Clegg, Heggestad, and Hopp-Levine (2009), it was demonstrated that when determining what cues work best for interruptive tasks in busy visual environments like cluttered displays, tactile stimuli worked very well in orienting users' attention because the redirection of attention is toward the location of the interruption. While non-directional tactile cues did not decrease performance on the primary task, it also failed to improve performance on the secondary task. This implicates that the benefits from tactile cues are exclusively exhibited in those that specifically redirect attention to the pertinent location that needed to be attended to. In addition to this, similar findings were revealed with auditory cues as well. As stated in the discussion of the study, auditory cues are often attributed as preemptive responses, and the auditory cues used in the study averted other ongoing tasks.

In another study that investigated pilots' general aviation performance with the utilization of mixed-modality simulation, Lancaster and Casali (2008) indicated:

> It is well known that an omnidirectional auditory display – as opposed to a visual display, which requires foveal attention (as with current data link) – enables the pilot to retain visual contact with primary flight displays and the external scene. However, although auditory warning displays foster perceived urgency when compared with visual warning displays, they also have been shown to interrupt or interfere with ongoing visual task performance (Latorella, 1998). This has been termed the preemption effect, in which an auditory stimulus reallocates pilot attention away from the ongoing (largely visual) flight task and has a detrimental effect on both traffic monitoring and flight path tracking (Helleberg & Wickens, 2003; Helleberg, Wickens, & Goh, 2003). (p. 184)

The above excerpt demonstrates that auditory preemption is a commonly exhibited phenomenon in many applicative settings such as aviation, wherein an auditory cue or distractor can, in fact, offset, interrupt, or preclude ongoing visual tasks, particularly in high fidelity environments.

Although auditory preemption has shown to be present in various settings such as pilot cockpits and alarm situations, there is one theory that challenges or conflicts with the preemption of the auditory modality. This theory, known as the multiple resource theory (Wickens, 2002), exhumes that there would be an apparent benefit to using multiple modalities at the same time (e.g. vision, tactile, and audition) because these concurrent tasks that are split between different visual or auditory stimuli would draw upon separate, distinct pools of modality resources, and, in effect, these tasks would be time-shared efficiently, and thus would not be interruptive in nature. This position regarding the multiple resource theory would hold true provided that the concurrent tasks do not share the same processing code, stage of processing, or response modality. As the multiple resource theory argues that multiple concurrent tasks can be performed efficiently alongside each other so long as they are utilizing separate modalities, it is argued that a discrete auditory task or stimulus preempts, or causes a brief lapse/hindrance of performance when performing a continuous visual task if and when the auditory task is attended to, which grants the auditory stimulus priority over the ongoing visual task.

Jeon et al. (2015) conducted a study in which participants were required to complete a dual task procedure for the experiment. In the primary task, participants engaged in a visual perceptual motor vigilance task which involved a simple ball-catching game wherein the objective was to catch as many balls as possible with an on-screen basket as they fell from the top area of the screen at an approximate rate of one ball per second. To indicate that a ball was successfully captured by the subject, the basket briefly flashed from black to green. To control the basket (it could only be moved from left to right along the x-axis at the bottom of the screen), participants placed their left index finger and left middle finger on the right and left arrow keys of a keyboard, respectively.

For the secondary task, which was an in-vehicle technology (IVT) menu navigation task, participants were required to navigate a list of songs made up of 150 songs from the Billboard 100 & Pop 100 and iTunes Top 100. A visual menu was created using #C using Centrafuse SDK programming tools. Menu items were displayed in alphabetical order while the participant was able to scroll downward and upward within the menu by utilizing up and down arrow buttons on a touch screen. The participant's objective was to reach the given target name in the song list menu as quick as possible. In addition to the visual display, the song menu list items had auditory cues when they were highlighted. When the item was highlighted with an arrow key, the auditory sound playback would play. All of the auditory cues were interruptible so that when the participant scrolled over to the next item on the menu, the new auditory cue would play but the previously triggered auditory cue would stop or be cancelled immediately before the new selection cue would play.

The overall purpose of this study was to explore the problems of distractions and task switching, and to find ways to mitigate the distraction issues that are presented in everyday driving situations. The results of the study revealed that auditory cues may allow users to operate and navigate the menus of IVTs while driving safely more efficiently. With auditory preemption being a factor in this type of design, however, a speech-based system might degrade drivers' abilities to respond to the braking of a leading vehicle, or competing with other cognitive resources needed to safely operate a vehicle.

In a paper that examines task interruption management as well as multimodal design (Lu et al., 2013), the authors aimed to investigate how the effects of interrupting task modality regarding the performance of any ongoing visual-manual task and the task that interrupts the ongoing task. The paper comprises three meta-analyses that contrast the performance for an ongoing visual task as well as interrupting tasks as a function of interrupting task modality which included auditory vs. tactile, auditory vs. visual, and single modality vs. redundant auditory-visual. Results and findings of the meta-analyses indicated that response times are faster for tactile interrupting tasks when considering low-urgency messages. Participants' accuracy is higher with tactile interrupting tasks regarding low-complexity signals but higher with auditory interrupting tasks for high-complexity signals. During high workload, redundant auditory-visual combinations are preferable for communication tasks. In conclusion, the results highlight how sense of touch should be reserved for simple notifications, while the auditory channel allows for better performance when a message is complex and urgent, suggesting the utilization of the auditory modality for alarms and alerts.

The aforementioned study brings some important questions to mind when discussing how modalities should be utilized for specific types of stimuli. For example, because the auditory modality should be used for urgent or complex stimuli, this can still impose the preemption of that modality. Perhaps an individual may need to read or pay visual attention to road hazards while driving considerably fast on a road or highway, and an auditory alarm sounds, which very well may create a lapse in performance for the ongoing task. How could tasks be implemented across different modalities in order to help in the effort of mitigating distraction in driving, whilst still allowing for the auditory modality to deliver critical hazard prevention signals or necessary alerts to drivers?

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Costa, R., & Friedrich, E. (2012). Inhibition, interference, and conflict in task switching. *Psychonomic Bulletin & Review, 19*(6), 1193-1201.

Jeon, M., Gable, T. M., Davison, B. K., Nees, M. A., Wilson, J., & Walker, B. N. (2015). Menu Navigation With In-Vehicle Technologies: Auditory Menu Cues Improve Dual Task Performance, Preference, and Workload. *International Journal of Human-Computer Interaction*, *31*(1), 1–16.

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Appendix B

Media Team

Hyundai Infotainment System Usability Presentation

April 30, 2019

Presented to: Dave Mitropolous-Rundus

Presented by: Amber D., Anika B., Anurag S., Chris D., Deepika T., Dennis G., Erzhena S., Maddie N., & Mariah H.

Arizona State University

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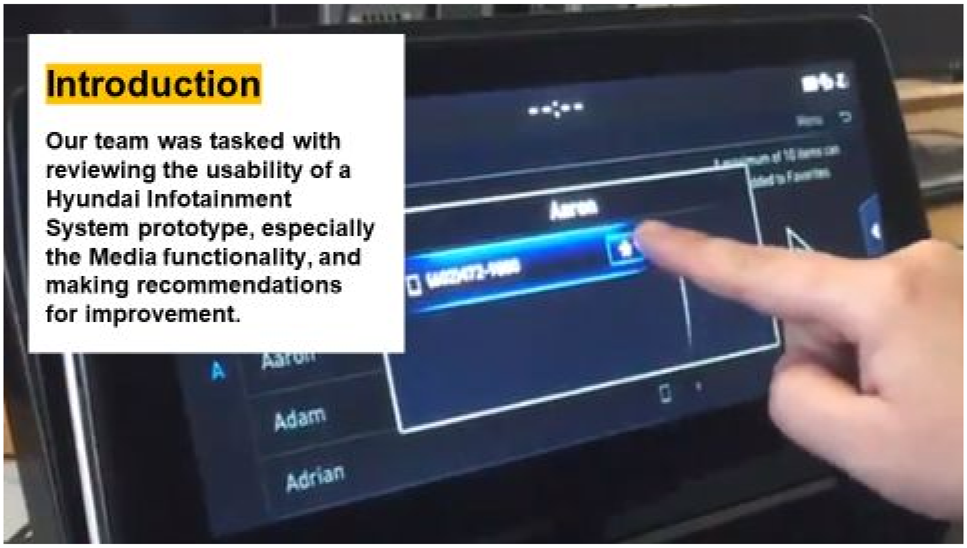


Heuristic Evaluation

Methodology

A heuristic evaluation is a usability inspection method conducted with a set of design principles known as heuristics. It focuses on elements that are inconsistent with an intuitive, usable experience.

The following sections of the Hyundai infotainment system were evaluated:

- Media
- Home screen
- Custom star button

Heuristics

1. Visibility of system status
2. Match between system and real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recover from errors
10. Help and documentation
11. Navigation
12. Use of modes
13. Structure of information
14. Physical constraints
15. Extraordinary users

Reference: http://www.id-book.com/firstedition/catherb/Complete_heurs.php

Severity Scale

0 – No issue

LOW – 1 Cosmetic or minor issues that can be distracting to users.

MEDIUM – 2 Issues may slow users down and can be frustrating.

HIGH – 3 Issues may inhibit accomplishing goals. Users may fail to complete tasks.

CRITICAL – 4 Users are unable to achieve tasks.

Reference: http://www.id-book.com/firstedition/catherb/Complete_heurs.php

Heuristic Eval: Intro Screen

Heuristics Violated:

- Aesthetic and minimalist design
- Help and documentation
- Visibility of system status

This is a lot of text to show a user when they start their car. I think they are trying to provide help, but it is overwhelming. It also does not stay on screen very long (could be positive or negative depending on the user)

Severity: 2-Medium

Recommendations:
Consider showing a little bit of information, then ask users if they want more or let them start driving.

Consider making the help tutorials accessible from inside the system and not just on the initial intro screen.

Heuristic Eval: Home Screen(s)

Heuristics Violated:

- Aesthetic and minimalist design

The home screen is actually 4 screens. This is too many options.

Severity: 3-High

Recommendations:

Consider grouping some of these functions by actions.

Heuristic Eval: Home Screen(s)

Heuristics Violated:

- Help and Documentation

The only help provided for users who may not understand how to operate the system is located when the system is first turned on.

Severity: 2-Medium

Recommendations:

Consider adding a tutorial widget or a widget that contains a set of instructions for users to reference without having to turn the system off.

Heuristic Eval: Ability to Customize Home Screen

Heuristics Violated:

- Extraordinary users
- Physical Constraints
- Flexibility and Efficiency of Use

To reorder the widgets the user has to drag the items around on the screen. The widgets often jump around and the system does not provide the user another way to customize.

This could be an issue for users with dexterity issues and users with disabilities.

Severity Level: 4-Critical

Recommendations: Consider adding a feature in the settings options that would allow the user to order the widgets without having to drag them, such as a numbered checklist.

Heuristic Eval: Saving Customized Widgets

Heuristics Violated:

- Visibility of System Status
- Navigation

Once the widgets have been arranged there is no option to presented to the users that gives them feedback that their choices will be saved. The user either has to push the back button or the set widget button which takes them to screen 2.

Severity: 2- Medium

Recommendations:

Consider adding a save button to the navigation when customizing screens.

Consider providing the user feedback that changes were saved.

Heuristic Eval: Set up the Custom Button (Star Button)

Heuristics Violated:

- Visibility of System Status

When in the process of reordering favorite menus, there is no indication that the elements must be long pressed (hold down on element with finger), and then dragged vertically to assign order. Additionally, when the user desires to save the current settings, there is no save confirmation. This feature is rendered quite dysfunctional because the system does not inform the user that the custom button assignment is being set.

Severity: 3-High

Recommendations:

Consider inserting a brief line of instruction at the top of the menu that says something like "Hold and drag elements to reorder."

Heuristic Eval: Pair Phones

Heuristics Violated:

- User control and freedom
- Help users recover from errors

When pairing a phone, the system automatically synchronizes the connecting device with call logs, phone call capabilities, access to messages, and media audio. This can be an issue for a user who desires to only use one of these functionalities, such as in a case where one phone shall be connected for phone calls and messages, and a different phone to play music with (perhaps another person's phone in the car playing music via bluetooth while the driver has phone call capabilities with his/her phone).

Severity: 3-High

Recommendations:

Upon connecting a device to the system's bluetooth for the first time, consider adding a prompt that asks the user which functionalities the bluetooth connectivity will comprise upon connecting. This will prevent another bluetooth already connected as a phone having its priority overwritten by the new device being connected if a user desires to use multiple devices for different bluetooth functions.

Heuristic Eval: Make a 10-Digit Phone Call

Heuristics Supported:

- Consistency and standards
- Match between system and real world
- Visibility of system status

This task was very straightforward, as a phone paired via bluetooth had all phone call capabilities categorized into tabulated menus, and all keypad symbols to manually dial a phone number were fairly universal (1-9 keypad, green call button, backspace). System also shows the combination of characters dialed, so the user does not have to remember which characters were dialed.

Severity: 0 No issues found

Heuristic Eval: Call Someone in Your Contacts List

Heuristics Supported:

- Consistency and standards
- Match between system and real world
- Visibility of system status

This task was easy. A contact was called when their name was tapped.

Severity: 0 No Issues found

Heuristic Eval: Search for a Number in Contacts

Heuristics Violated:

- Match between system and real world
- Recognition rather than recall
- Navigation

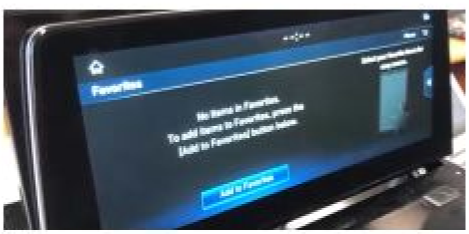
The ability to search through contacts is not clear from the contacts list screen. The user must click into the menu, select search contacts and then either type the contact in or use the voice feature from that screen.

Severity: 3-High

Recommendations:

Consider adding a search bar on the page to reduce the number of clicks it takes to get to the search feature.

Heuristic Eval: Save a Contact as a Favorite



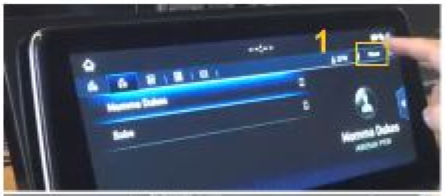
Heuristics Supported:

- Visibility of system status
- Help and documentation

The zero state prompts users to add a favorite, from this screen, if there are none.

Severity: 0- No issues found

Heuristic Eval: Save Additional Contacts as Favorites



Heuristics Violated:

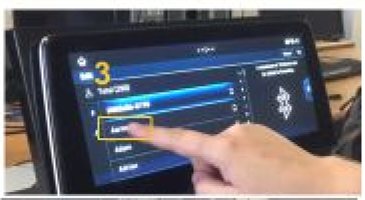
- Flexibility and efficiency of use
- Match between system and real world
- Structure of information
- Flexibility and efficiency of use
- Consistency and standards
- Visibility of system status

It took the team multiple attempts to add additional contacts to favorites after the first one. At first they didn't find it and kept accidentally calling people they were trying to favorite.

It turns out there were 4 steps and screens. The first step was hidden under a secondary menu. The label to "edit" was not the word users expected to see for adding a favorite.

(continued on next slide)

Heuristic Eval: Save Additional Contacts as Favorites



Tapping a contact opened a popover, in this screen. This is inconsistent to how tapping a contact in other parts of the system made a call.

When users tap the star to favorite the contact, there is no positive feedback indicator that they were successful.

Severity: 3- High

Recommendations:

Consider using the contacts that are already favorites on the user's phone so they do not need to do anything.

Alternately, keep the "add to favorites" button from the zero state screen at the bottom of the favorite contact list, so they can get there with one tap.

Heuristic Eval: Unpair Your Phone

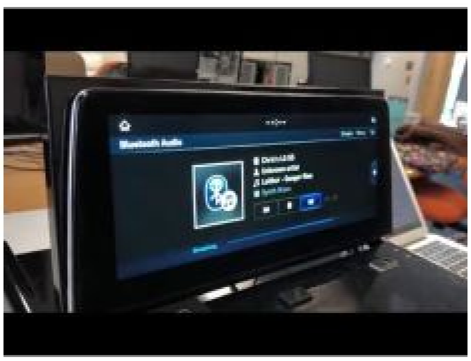
Heuristics supported:

- User control and freedom
- Error prevention

This task was easy to carry out. "Setup" makes sense as the place for this function. The user taps the device they want to unpair. Then they are prompted to confirm their action (error prevention).

Severity: 0- No Issues found

Heuristic Eval: Play Music Saved to Phone



Heuristics Violated:

- Recognition rather than recall

When selecting the source of audio (bluetooth, USB, etc.), the options available do not look like buttons. This could cause confusion, and can impede time on task for selecting the desired source for media audio.

Severity: 2-Medium

Recommendations: Consider providing a line of brief instructions to the user at the top of the menu that informs the user to "select a source from below."

Heuristic Eval: Play Music on a USB Stick

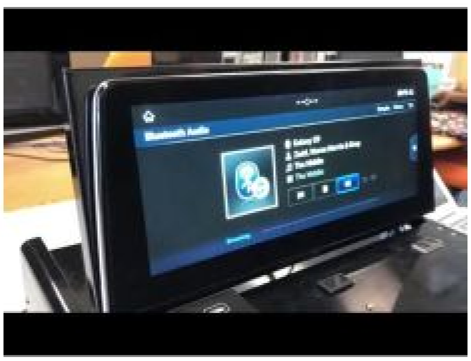
Heuristics supported:

- Visibility of system status
- Match between system and real world

This task was extremely easy to carry out, as music started playing immediately after a flash drive was plugged in, needing no user input at all. Additionally, upon plugging the drive into the port, the system gave feedback that said "reading USB" immediately prior to beginning playback. This allows the user to know what is going on all the way up until the goal is complete.

Severity: 0- No Issues found

Heuristic Eval: Play Music Using a Streaming Service



Heuristics Violated:

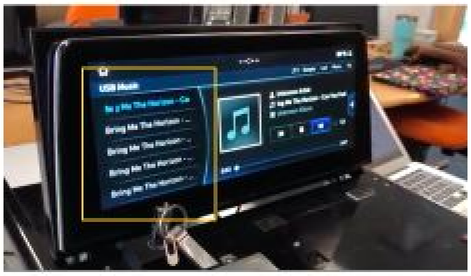
- Flexibility and Efficiency of use
- Navigation

The system is able to play music from streamable services like Amazon or Pandora, but the playback status is not visible unless the user is on the proprietary media streaming submenu.

Severity: 2-Medium

Recommendations: When any source of media is in use or playing, consider providing a status widget next to the home button along the top row of icons that can be pressed to take the user to the corresponding menu, i.e. the media streaming menu.

Heuristic Eval: Choose Different Songs within an Artist



Heuristics supported:

- Visibility of system status
- Match between system and real world

This task was easy to carry out, the list of songs was already showing on the left. The user just needs to tap one.

Severity: 0-No Issues found

Heuristic Eval: Choose Different Artists

Heuristics supported:

- Visibility of system status
- Match between system and real world

This task was easy to carry out. Users tap menu (a common convention) and a list appears on the left. Artists is an option.

Severity: 0-No issues found

Heuristic Eval: Search for Music

Heuristics Supported:

- Structure of information
- Consistency and Standards

When the user is on the USB Music menu, the system will recognize mp3 audio files, and will categorize them based on the following categories: Folders, songs, albums, artists, and recently added. This type of categorization allows the user to more quickly make a selection. In addition, the current category is highlighted in blue to inform the user which category is being viewed.

Severity: 0-No issues found

Heuristic Eval: Multiple Screens and Slide Menus

Heuristics Violated:

- Help users recover from error
- User control and freedom
- Use of modes

If the user selects split screen from the menu option multiple screens pop out and block the main information on the screen. The only way to close the menus is to wait for them to time out.

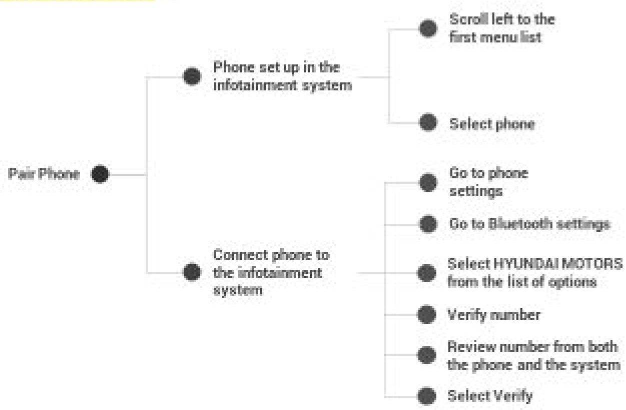
Severity: 3-High

Recommendations:

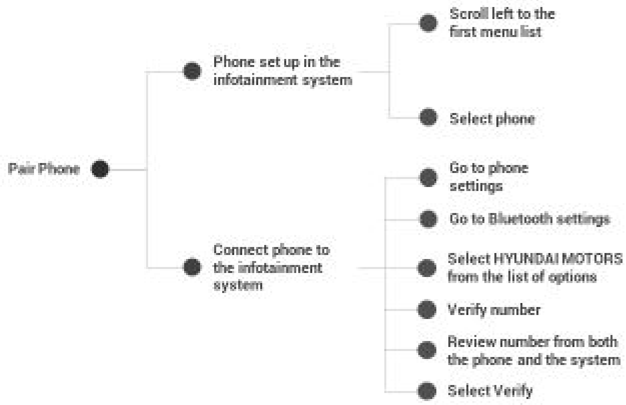
Consider adding a icon that will close the menus as needed that fits standard conventions such as a X.

Task Analysis

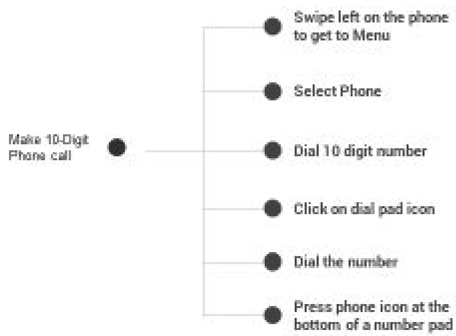
Task: Pair Phone



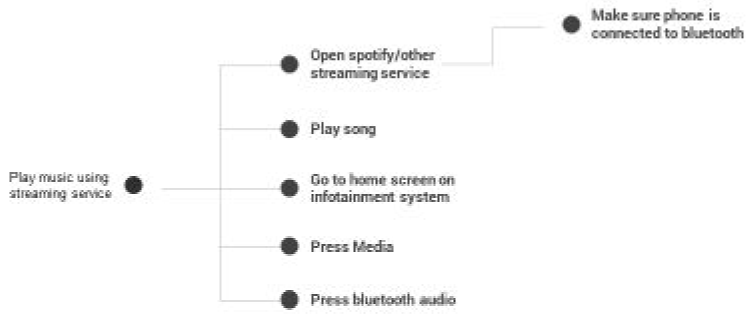
Task: Pair Phone



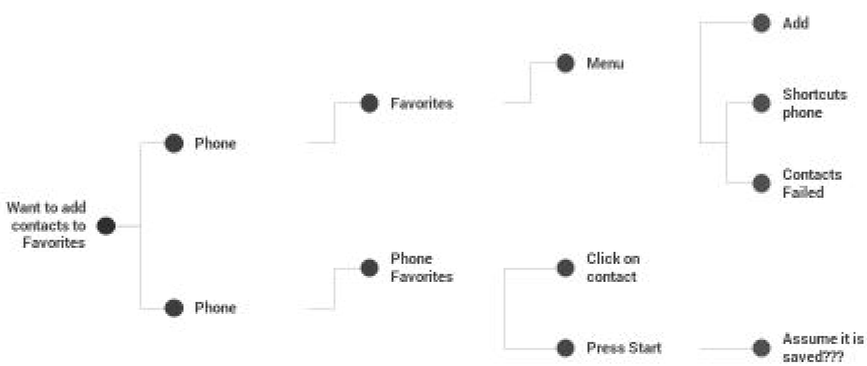
Task: Make 10-Digit Phone Call



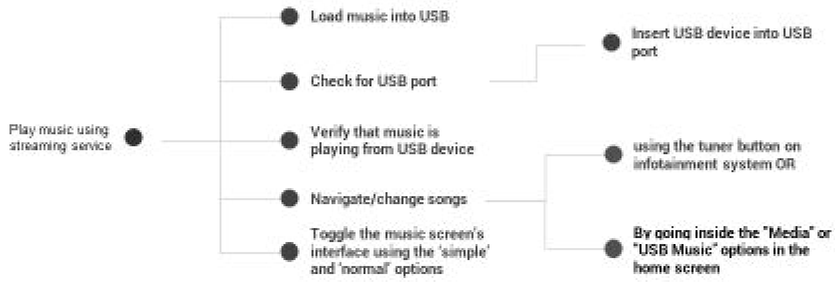
Task: Play music from streaming service on phone



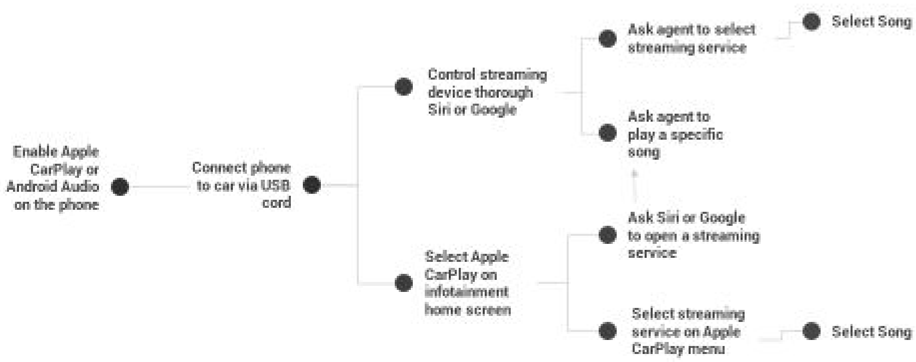
Task: Add Contacts to Favorites



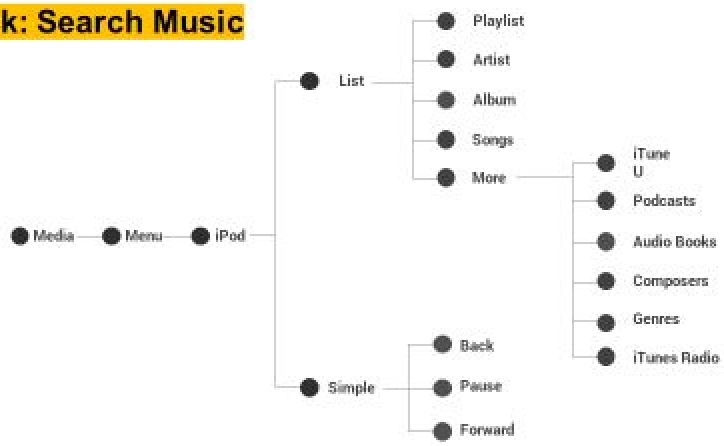
Task: Play Music from USB Stick



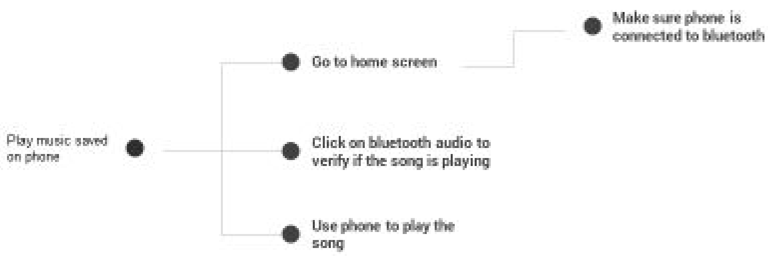
Task: Stream Music from Phone via USB



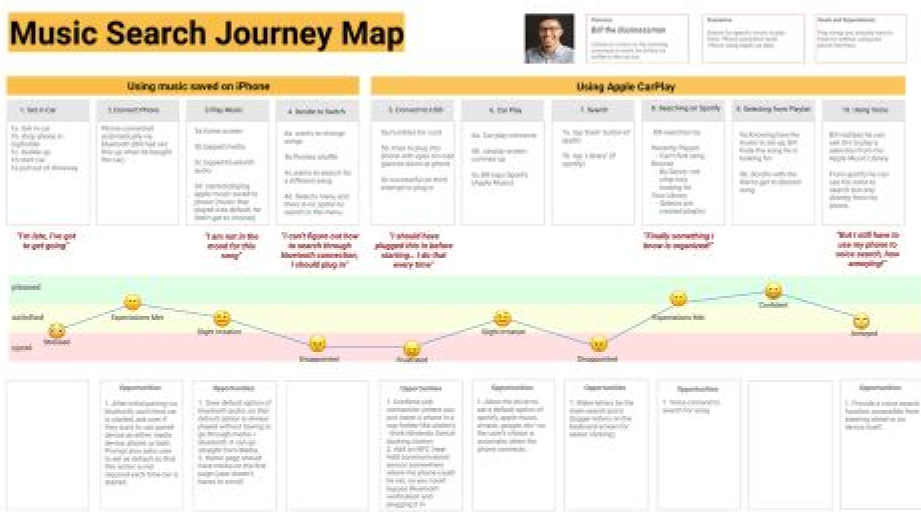
Task: Search Music



Task: Play Music Saved on Phone



Journey Map


Music Search Journey Map
Using music saved on iPhone
Using Apple CarPlay

Usability Testing

Usability Testing Summary

A usability test was conducted on a Hyundai infotainment prototype to identify problems that users may encounter and suggest improvements to make the infotainment system more useful and usable. 3 participants completed 5 tasks while operating a driving simulator.

The usability metrics we measured were number of glances off the road, time on task, and success rate.

- Only 1 of the 5 tasks was completed successfully by all 3 participants.
- Connecting to CarPlay was not completed by any of the participants successfully.

Methods

- An in-person moderated usability test was performed on April 11
- 3 participants completed 5 tasks with the Hyundai prototype, while operating a driving simulator
- They were asked to "think aloud"
- The metrics gathered included:
    - Number of glances off the road
    - Task success rate
    - Comments made by participants

Testing limitations and constraints

- Testing was limited to a week from test plan to final report.
- The number of participants was constrained by the testing schedule.
- Testing only occured on one day due to the having to share the lab and the simulator with other teams.

Methods: Participants

- Participant 1: Female, 55-64 years old
  Drives a 2018 Mazda 3, infotainment is not touchscreen. She usually listens to the radio, but uses Pandora or Amazon Music otherwise.

- Participant 2: Male, 25-34 years old
  Drives a 2002 Ford Taurus, and there is no infotainment system, though he is familiar. He usually listens to CDs or Pandora.

- Participant 3: Female, 35-44 years old
  Drives a 2007 Chevy Suburban & 2015 Kia Soul, and is used to BlueTooth and Nav but not an infotainment system. She usually streams her music from Spotify.

Methods: Tasks

1. Take a look at this home screen for a bit. Tell us what you think you do here. Take a few minutes to explore the system and think out-loud while doing so.
2. Pair your phone to the system.
3. Call someone from your contacts list that has a name that starts with the letter "M".
4. Find a song called *Kirby* by Aesop Rock on your USB.
5. Now you want to use your favorite streaming service through Apple CarPlay/Android Auto. How would you connect to Apple CarPlay/Android Auto?
6. Search for music from your favorite artist using a streaming service of your choice.

Methods: Pre-test Questions

1. Gender
2. Age range: 18-24, 25-34,35-44, 45-54,55-64, 65+
3. How many years have you been driving?
4. What kind of car do you drive (make, model, year)?
5. Do you have an infotainment system in your car? If so, describe it.
6. How do you generally listen to music while driving?
7. How do you usually listen to music on your phone? What streaming services do you use?
8. Type of Phone (brand and model)

Methods: Post-test Questions

1. Describe your overall experience with the system today.
2. What did you enjoy about the system? Why?
3. What if anything caused you frustration? Why?
4. Suggestions for improving the system? Additional Feedback?

Results: Overview

Task	Success Rate	Average Time on Task (range)	Average glances off road (range)	Notes
Pair Phone	3/3	0:58 (0:49–1:07)	19 (15–24)	One of the participants used a USB cord instead of connecting wirelessly with Bluetooth.
Search for contact with letter M	2/3	1:08 (0:43–1:53)	23 (19–24)	
Find song on USB	2/3	1:08 (0:43–1:50)	26 (19–38)	
Connect to Apple CarPlay/Android Auto	0/3	1:48 (1:21–2:13)	29 (21–33)	Two of the participants did not understand that they had to use the cord to connect.
Search for Artist using streaming service	1/3	0:38 (0:29–0:47)	8 (6–9)	Time and glances based on 2 of 3 users

Results: Explore the Home Screen

- One of the users wasn't aware of the multiple panels/slides in the home screen which resulted in many of the features not being seen by her.
- All the users were confused with the "Blue Link Activation" option and the "Speed Distribution" phrase. One of the user got confused with some sort of bluetooth feature.
- Users liked the "Data Services" option to view the weather status.
- The menu options should return to the same screen from where that option was launched. One of the user faced this problem when exploring the maps option.
- The "FCEV" option was unclear to users and interpreted it as something related to fuel because of its its symbol.
- The top 3 options desirable at the home screen were Music, Maps and Phone.

"Blue Link Activation? No clue what that would be"

"Speed Distribution? Apparently it makes us feel bad for speeding!"

Results: Pair Phone to the System

- All 3 participants completed the task successfully
- When instructed to pair their phone with the system, one participant did not pair their phone via Bluetooth, using a USB cord instead.

Results: Call a Contact that Starts with "M"

- 2/3 Participants completed the task successfully.
- 1 Participant could not complete the task because the phone paired but the contacts did not sync.
- 1 Participant wanted to use voice control

  "Okay, google. Call Mom"

Results: Find a Song on Your USB

- 2 participants tried to use voice control
- Participants took their eyes of the road an average of 26 times in 1 minute 8 seconds (~5 times to plug in the device, ~21 to find the song or give up the task)

Results: Connect to Apple CarPlay/Android Auto

- All participants were not aware they needed to use a cord to use this feature.

Results: Search for Artist in a Streaming Service

- 1 participant used voice control (Siri)
- 1 participant used phone instead of infotainment system, and veered off the road

Video clip showing struggle with finding the back button and frustration with not having a search option. P1 was using Apple Music connected to Apple Play.

Results: Open-ended Feedback

- 1 participant said "It's nice having a touch screen so that you don't have to use your phone." However, she tried to use her phone on at least 2 of the tasks.
- 2 participants said they wanted a manual (a physical printed version)

Results: Observations Noted Across Participants

- At the beginning, all 3 participants said they wouldn't use the infotainment system while driving.
- They expressed concerns about distraction and safety throughout the test.
- All 3 participants used the touch screen. We did not observe any use the control knob.
- All 3 participants tried to use voice control during the test (Siri or Google).

Results: Terminology

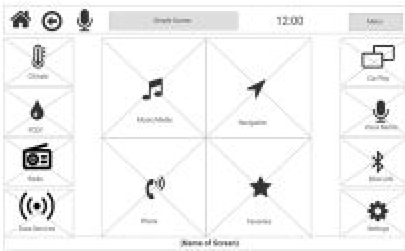
- **Media**
  2 participants understood the term "Media" while 1 participant didn't and said she was looking for labels such as "Music" and "Search"
- **Blue Link**
  None of the participants knew what "blue link" meant, 1 participant assumed it was a "proprietary Hyundai thing"
- **Speed Distribution**
  None of the participants knew what "speed distribution" meant

Summary: Recommendations

- Simplify the home screen to minimize scrolling.
- Inform the user on the screen of Apple CarPlay or Android Auto that their phone will need to be connected with a cord.
- Upon connecting a USB drive device to the infotainment system, consider integrating an interactive pop-up that allows the user to go to a menu encompassing a wide variety of USB drive options (searching for music, organize by category or genre, browse certain artists or lists, etc.).
- Simplify searching for a contact

Wireframes of Ideas for Improvement

Wireframe: Home



Home Screen Default

Home Screen Simplified

Global Menu

Home Screen Simplified Menu Expanded

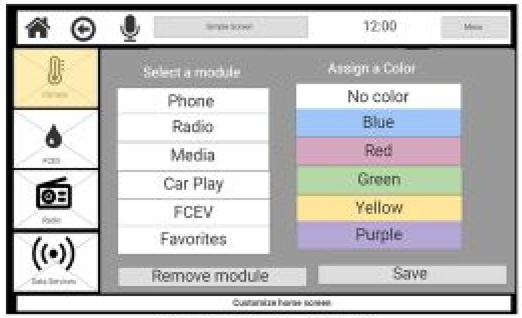
Global menu items will include the most prominent action items so they are easy to locate without having to drill too far down into the navigation.

It will also provide the user access to options that they may have removed during customization.

It offers an item that closes the menu without the user having to swipe to close the module or wait for it to time out.

Wireframe: Customizing Home

3.



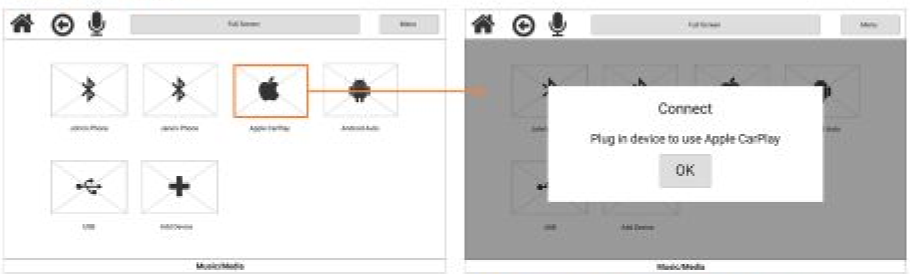
Settings>customize>Home Screen>
Module selected

2

Settings>customize>HomeScreen

Wireframe: CarPlay

Clicking **Media/Music** on the home page takes you to a screen showing media types



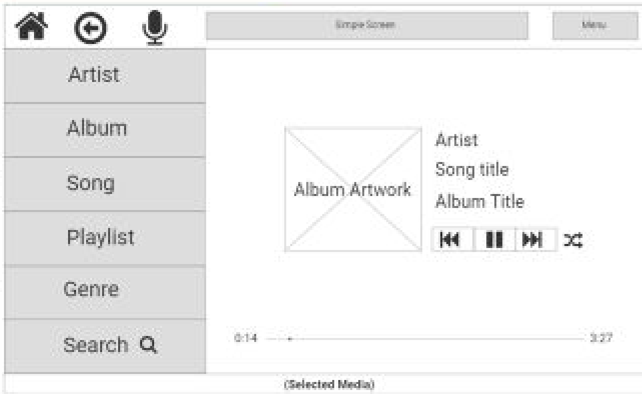
If you attempt to use a media type that is not available, the system will give you a prompt

Wireframe: Music Search

When music is accessedon the prototype, the inital left hand side menu is a list of songs. In addition the "List" button on the top right screen has to be pressed to bring up options like Album, Artist, Song, etc.

List may not be easily recognized as access to the category menu. The existing Menu button on the prototype brings up unecessary things like song information, shuffle toggle (there is already a shuffle toggle on the min screen), hide current file (what purpose does this serve?), and sound settings.

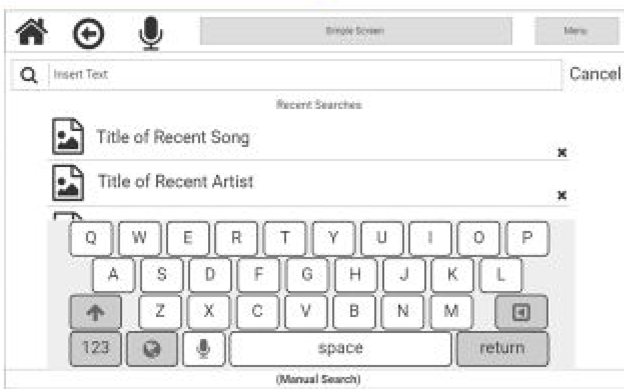
To make searching for music more efficient, categories are on the left menu instead of the list of titles of songs/artists. In addition, a search function is included to search manually with a keyboard or voice search using the microphone icon.



Wireframe: Music Search

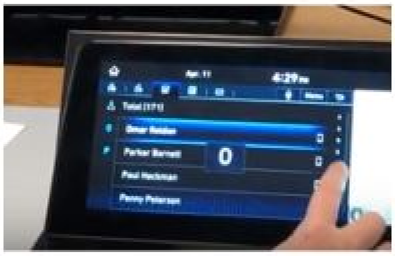
This would search through all categories and retreive the most relevant results.

Having the keyboard search function eliminates having to scroll through different categorical menus using the alphabet.



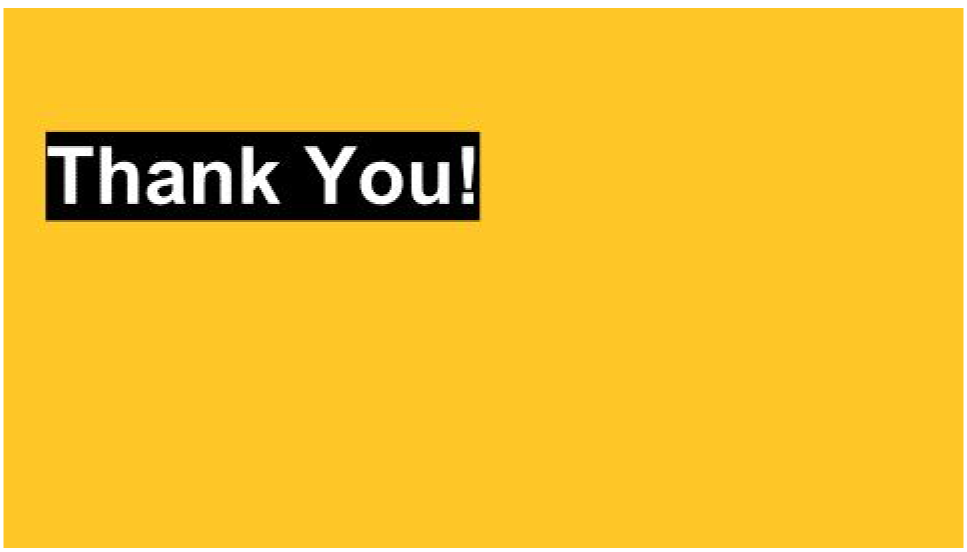
Wireframe: Call from Contacts List

Current Designs:



Wireframe: Call from Contacts List

More search functionality; User can now use the keyboard (QWERTY) *or* scroll functionality that they are familiar with.



Appendix C

The research question for my study revolved around how the ages of participants may have affected an individual's subjective confidence in an artificial intelligence entity (in this case, a mechanical robot represented in a virtual world). These exploratory results can be used in future investigations or analyses to peer into other reasons why participants may have had high or low levels of trust in their interactions with the robot.

The data being investigated involves trust scores for human-AI interaction, which are derived from answers to a set of questions asked to each participant. Each question (pertinent to how much the participant trusts the automation) can be answered with any number ranging from 1 to 7, indicating low trust to high trust, respectively. The trust scores represented in the below graph for each participant are the averages of 25 separate questions that each participant responded to with a number (between 1 and 7) to indicate their level of trust.

Participants whose ages lie somewhere between the range of 18 to 25 years generally retain measured levels of trust that are higher than other participants. Although further investigation is definitely needed to verify why this may be, a postulation can be made regarding a participant's comfortability, or perhaps familiarity with technology, as it relates to their trust in automation, considering those who belong in the age range of individuals who grew up around the start of the digital age tend to have familiarized themselves more with modern technology.

Figure 1:

x = Participant ID

y = Trust score (calculated by averaging the responses (1-7) of each of the 25 questions participants were asked

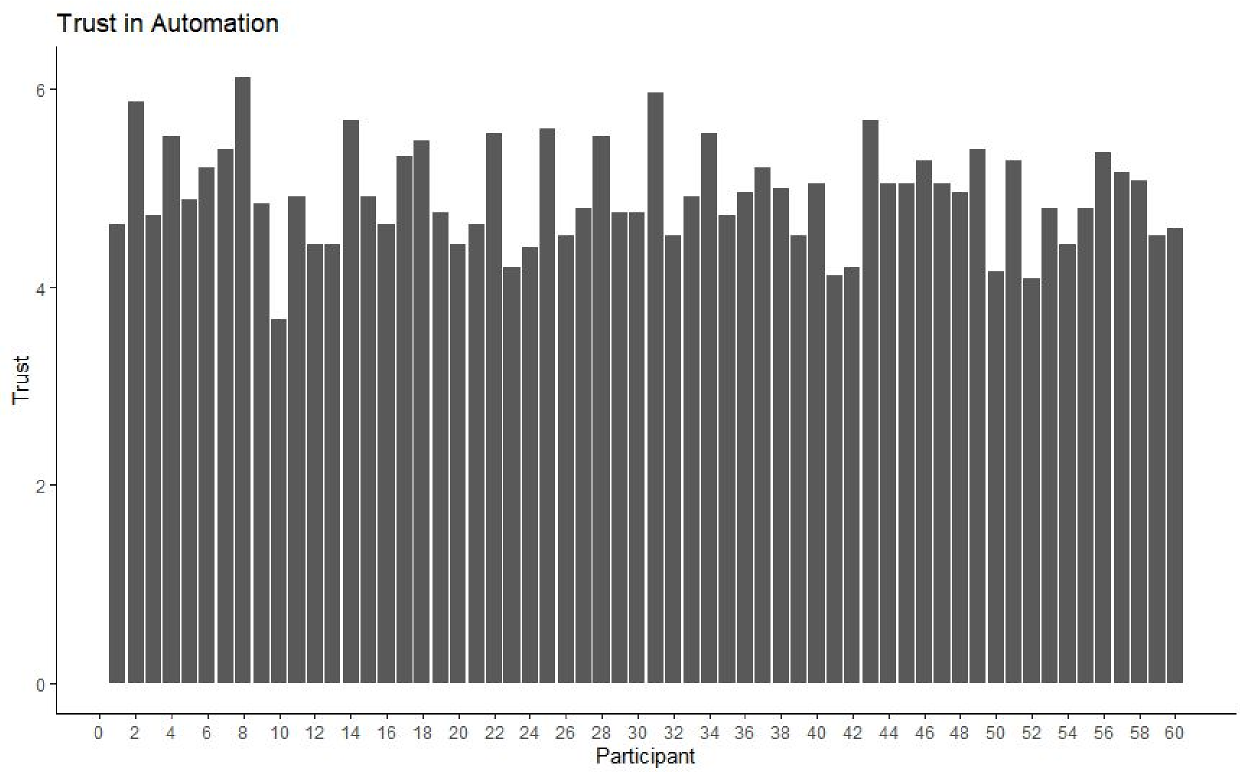


Figure 2:

x = Participant ID

y = Age (in years) of corresponding participant

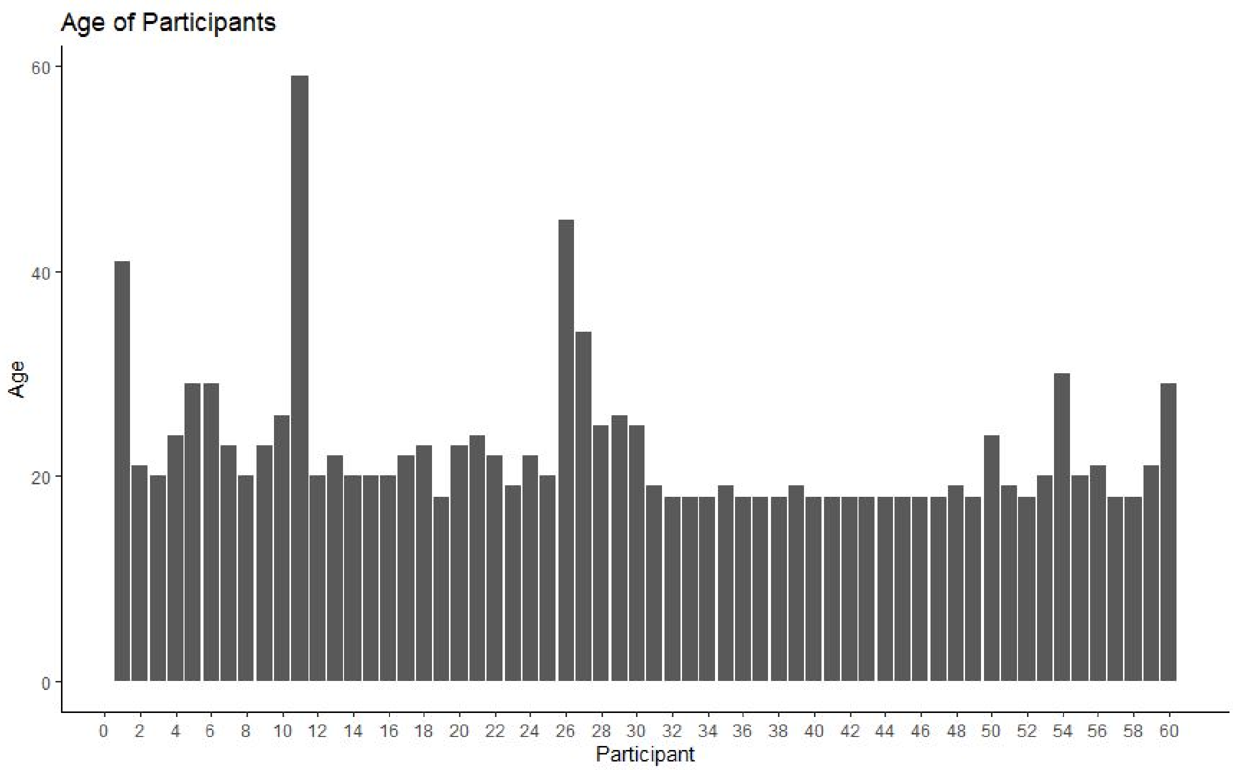
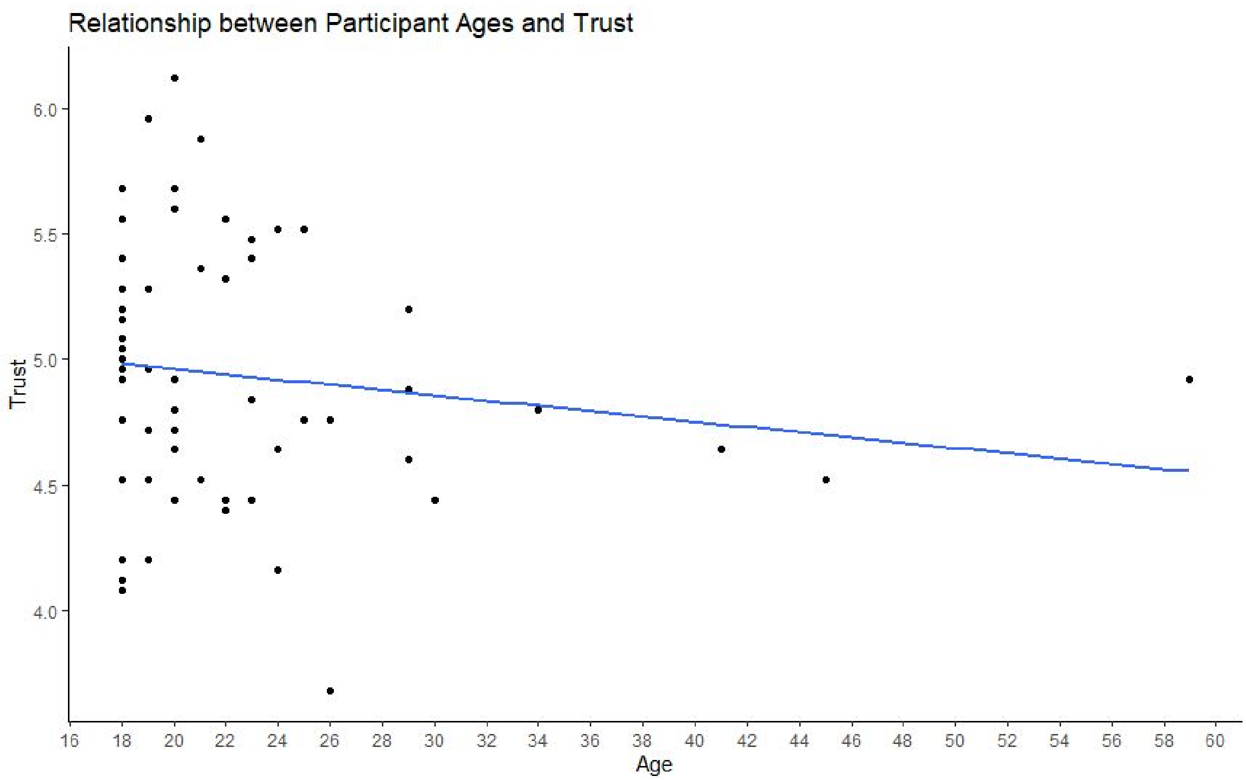


Figure 3:

x = Participants' ages (in years)

y = Trust score (calculated by averaging the responses (1-7) of each of the 25 questions participants were asked

According to the below scatterplot, a slight negative correlation (Pearson's r = -0.1491012) between the levels of trust and the ages of participants is exhibited. This suggests that as age increases, the level of trust in automation slightly decreases. Furthermore, within the young adult age range of 18 to 24, there appears to be little to no relationship to levels of trust.



Data: https://drive.google.com/open?id=16r0KwgtFLxGtmMpRuVY7IeB_kcemIxZ_