Overview

1. The Project

Christina Wasson

Introduction

This project, ***The Social Life of Cars***, was conducted for Nissan Research Center Silicon Valley by my Fall 2014 Design Anthropology class at the University of North Texas (UNT). Our client contact was Brigitte Jordan, Consulting Senior Corporate Anthropologist. Our interactions with Brigitte Jordan were highly collaborative. She showed an impressive level of dedication by participating in our weekly class meetings via Skype, as well as visiting us in person three times over the course of the semester. She was also a strong intellectual partner throughout, working closely with me to develop the project goals and research design before the class started, and providing feedback during the semester to keep the class focused on what was most useful to the Nissan Research Center.

Our project was an exploratory ethnographic study of the social life of the car. The goal was to generate a foundational understanding of how Americans understand and drive their cars. The study laid the groundwork for future ethnographic research projects that can take a deeper look at more narrowly defined topics.

The research questions for this study were:

- Mapping out the social life of the car, that is, specifying the web of relationships and contexts in which the car is embedded
- Making driving visible – in parallel to Lucy Suchman's 1995 concept of "Making Work Visible" – what actually happens when people are driving? What do their interactions look like with different aspects of the car, its spaces, technologies, and tools, and other people inside or outside the car?

This report details the results of our project.

We should note that use the phrase "**study participant**" to refer to the subjects of our research. The term "subject" is generally avoided by anthropologists today because it conjures up images of experiments. And "informant" has had negative connotations since Watergate.

Organization of Report

The report includes 12 chapters, grouped into four sections.

Overview

The first section includes two chapters.

- Chapter 1 – which you are reading – explains the background and overall parameters of the project
- Chapter 2 describes our ethnographic methods and who our study participants were

Driving Behaviors

The second and largest section of the report examines what our study participants do while they are driving. Perhaps the greatest strength of our study is that we were able to actually accompany people *while they were driving*, observing and videorecording their activities. Drive-along studies are surprisingly rare.

We found driving behaviors to be an artful mixture of attending to the inside and outside of the car at all times. Drivers simultaneously monitor the road, interact with passengers, engage with absent friends via smartphone, check gauges on their dashboard, manipulate objects in the car such as beverages, sing along to music, and so forth. These behaviors are amazingly complex and layered. In order to describe this mix of driving behaviors coherently, we have pulled apart the layers and addressed them in separate chapters.

- Chapter 3 describes ways that drivers attend to the environment and people outside of the car
- Chapter 4 describes ways that drivers attend to people in the car
- Chapter 5 describes ways that drivers attend to people who are virtually present via smartphone
- Chapter 6 describes ways that drivers attend to car features and objects in the car
- Chapter 7 describes other activities that drivers engage in

Each of these chapters consists of two parts:

- First we present the research findings
- Then we present the implications – design ideas and possible social consequences that follow from our research findings

The Role of the Car in People's Lives

In the third section of the report, we describe three themes that emerged in our research about the role of the car in people's lives.

- Chapter 8 describes the car's value as a "mobile locker"
- Chapter 9 describes how the car is used as a means to accomplish work
- Chapter 10 describes the utilitarian relationship between cars and drivers

Like the previous section, the chapters in this section consist of two parts, first the research findings and then the implications.

Ideas for the Future

The last two chapters in our report consider ideas for the future.

- Chapter 11 describes study participants' perceptions of self-driving cars
- Chapter 12 describes a design idea that emerged from class discussions, the modular pod concept; it relates to research findings from a number of different chapters

Other Deliverables

In addition to this report, we have provided Nissan Research Center Silicon Valley with two other deliverables:

- The slide deck from our final client presentation on December 10, 2014; it summarizes findings from every chapter of this report, and includes video clips
- ***Methodology in Action***, a short video that explains our research methods

A Few General Reflections

In addition to the implications described in each chapter, the class noted a few broad trends that may result from the adoption of AV, based on our research findings about how people engage with their cars. First, although the adoption of new technologies is often associated with a reduction in social behaviors, we suggest that AV may *increase* social behaviors. When drivers no longer need to monitor the road, they may use that extra time to interact with friends and family. It would be a mistake to assume that people will necessarily use that time to do more work.

Second, the modular pod concept described in Chapter 12 could, counterintuitively, have negative consequences for the environment. If considerable numbers of families acquired multiple pods, this could lead to an increased consumption of natural resources, since most technologies use a variety of metals and minerals that must be mined, often in unsustainable ways. Furthermore, these components are often shipped long distances, which would use additional fuel, often of an unsustainable variety. So although the adoption of AVs could introduce more sustainable driving habits into daily life, it is important to note that the energy saved by more efficient driving could be undone by an overall increase in the consumption behaviors surrounding cars.

Third, a shift in jobs may result from the adoption of AV. Some jobs may disappear, for instance delivery personnel, whether of pizzas or packages. Other jobs may increase; for instance, the industry for reducing motion sickness in cars may grow more lucrative.

Finally, our research findings have mixed implications for car-sharing programs. The specific pros and cons are described in Chapters 10 and 12.

The Students

Figure 1.1. Students in Design Anthropology Class

The students in this class included:

- 10 Master's students in Anthropology
- 3 MFA students in Design with a concentration in Design Research
- 2 undergraduate Communication Design majors (initially 4, but 2 dropped out during the semester)

- 1 PhD student in Information Science with a concentration in Decision Science and Information Technology

The class was therefore mainly a mix of anthropology and design students, with one student from information science for additional diversity and insights. This mix produced a productive interdisciplinary collaboration. The project benefited from the expertise of each discipline. Figure 1.1 provides some snapshots from class meetings.

The students in this class contributed a tremendous amount of hard work, insight, and creativity to the project. Figure 1.2 illustrates this dedication. It shows how one of our students, whose fieldwork partner dropped the class right before the fieldwork, not only carried on with the fieldwork on his own, but did an unusually thorough job. This image is a screen shot from the videorecording of study participant Sharknado commuting from home to work. Sharknado is using Snapchat to send a picture of his experience to a friend. Student researcher Stephen Gonzalez is in the back seat videorecording Sharknado. But who was behind the camera that produced this image? It turned out that Stephen had mounted a second videocamera on the dashboard. So even though Stephen was on his own, he managed to videorecord his study participant from *two separate angles* during the driving observation!

Figure 1.2. Sharknado Captured on Two Videocameras at Once

History of Design Anthropology Class

I have been teaching a course in Design Anthropology at UNT since 2002, and before that I taught a related course at DePaul University. To the best of my knowledge, UNT is the only university that offers a course in Design Anthropology through an Anthropology Department (a few universities offer related courses through Design or interdisciplinary programs).

I believe that students learn a great deal from conducting a research project for a client. I try to structure the work as much like a consulting project as possible, so that students can learn about engaging with clients and collaborating with people from other disciplines. Previous clients for class projects include:

- Motorola Mobility Inc.
- Microsoft
- Dallas/Fort Worth International Airport
- Field Museum in Chicago

My most common collaborator has been Crysta Metcalf at Motorola; we did five class projects together (Wasson and Metcalf 2013).

I gained expertise in the field we now call design anthropology by working as a project manager for E-Lab, a design firm that used anthropological research to develop new product ideas, in 1996-1997 (Wasson 2000, 2002). I was also a founding organizer of the Ethnographic Praxis in Industry Conference (EPIC), which has become the primary venue for design anthropologists and their interdisciplinary colleagues to meet (http://epiconference.com/).

2. Methods and Study Participants

Stephen Gonzalez and Cate Ferman

Methods

This project followed an ethnographic research approach. This means that the research process was exploratory and inductive; qualitative rather than quantitative. Ethnographic methods are particularly well suited to discovering the unknown, when it is too early to formulate hypotheses to test because the terrain has not yet been well mapped. Ethnographers are good at uncovering the unexpected. They do this by spending time with people as they go about their daily lives, examining people's behaviors in their natural setting rather than a laboratory context. They observe people carefully, and conduct in-depth, open-ended interviews. Ethnographers then rigorously analyze these observations and interviews to identify patterns, and develop implications for new product development.

The research design for the project was approved by UNT's Institutional Review Board, as required of all UNT research that may be published or presented at conferences.

Data Collection and Recruiting

Our data collection was split into three components:

- Pre-driving interview
- Driving observation
- Post-driving interview

Researchers worked in teams of two, filming each component in order to facilitate the analysis process. Interviews were conducted using an informal and semi-structured style. The location of interviews varied from households to restaurants, and while researchers had interview guidelines, the semi-structured nature allowed them to go off script and pursue lines of inquiry wherever they might appear.

The nine study participants for this research were chosen through convenience sampling. There were two reasons for this: 1) Being a class project, our timeline for completion did not allow for an extensive recruiting process and 2) Our methodological approach demanded a certain degree of trust between participants and researchers. Participants needed to be comfortable in allowing access to their home and vehicle. This resulted in the following:

- 1 study participant was the sibling of a researcher
- 6 were friends of a researcher
- 2 were related to friends of a researcher

1. Pre-Driving Interview

In this stage, researchers gathered demographic information and information about the study participant's vehicle. Some other questions included were: How do you feel about your car? Who drives this car? How

is the car used? We also had participants give researchers a physical tour of their car, both inside and outside, allowing them to describe their vehicle in their own terms.

2. Driving Observation

This stage was initially designed around the idea that researchers would ride along with participants during a "typical" drive. Researchers would record the driver and his/her interactions with the vehicle and passengers along with the outside world (other drivers, pedestrians, the environment etc.) asking questions along the way. Our approach was eventually tweaked as UNT's Institutional Review Board raised concern about distracting the driver and ultimately causing an accident. Researchers would no longer bombard participants with questions while driving, but participants were encouraged to narrate their own driving experience. Using common sense and reason, researchers would only pose questions at appropriate times (for example at a stop light) and engage with the driver in conversation only as naturally directed by the driver.

3. Post-Driving Interview

The post-driving interview usually occurred on a later date than the driving observation. This is where the semi-structured guideline came in handy, as researchers were able to orient their questions towards their particular study participant's driving experience. In general, this interview was designed to elicit a more in-depth and critical discussion of driving, driving behaviors, and the car itself. Some of the questions included were: What does the car do from its point of view? Who takes care of the car? Is it personalized? Are there stories attached to this vehicle? What would your ideal car be? What are its functionalities? If able, researchers were also encouraged to play back clips of the driving observation in order to get the participant's point of view on their own (possibly unconscious) actions.

Analysis

We collected nearly 18 hours of video in total, although it should be noted that when possible, multiple cameras were used to record the driving observation in order to capture multiple angles. Teams averaged around 2 hours of video per participant. Using this video data, each of the nine teams was responsible for writing field notes for each of the three components of the research, ultimately resulting in 27 sets of field notes. The field notes provided detailed descriptions of the video recorded interactions, noting and time-stamping discussion topics in the interviews and behavioral instances in the driving observation.

Our initial analysis of the data occurred in class meetings over a three to four week period, as roughly 3 teams presented their individual findings each class session. These presentations highlighted key instances and information researchers found relevant or interesting. After these groups presented their data, the remainder of class time (around 20-30 minutes) was spent creating a brainstorm document divided into three sections: specific instances, patterns, and design or social implications.

As more teams presented additional instances, patterns began to emerge and were codified into our brainstorming document. Patterns could shift or merge, and some instances associated with one pattern eventually found themselves more strongly aligned with other patterns. Eventually, these patterns would form the chapter topics in this report.

In Week 11 of the semester, students selected chapter topics. Each student then subjected all 27 field notes and the associated video to an exhaustive examination of their chapter topic. To facilitate rigorous analysis, students used a qualitative data analysis program called Dedoose. Dedoose is a browser-based

program and as such was easy to work with and collaborate on when not in class. With Dedoose, researchers were able to code every instance (as noted in the field notes) and associate it with the appropriate related pattern. Students created over 90 codes in Dedoose, and applied the codes to nearly 1000 field notes excerpts. Figure 2.1 provides a screen shot of Dedoose.

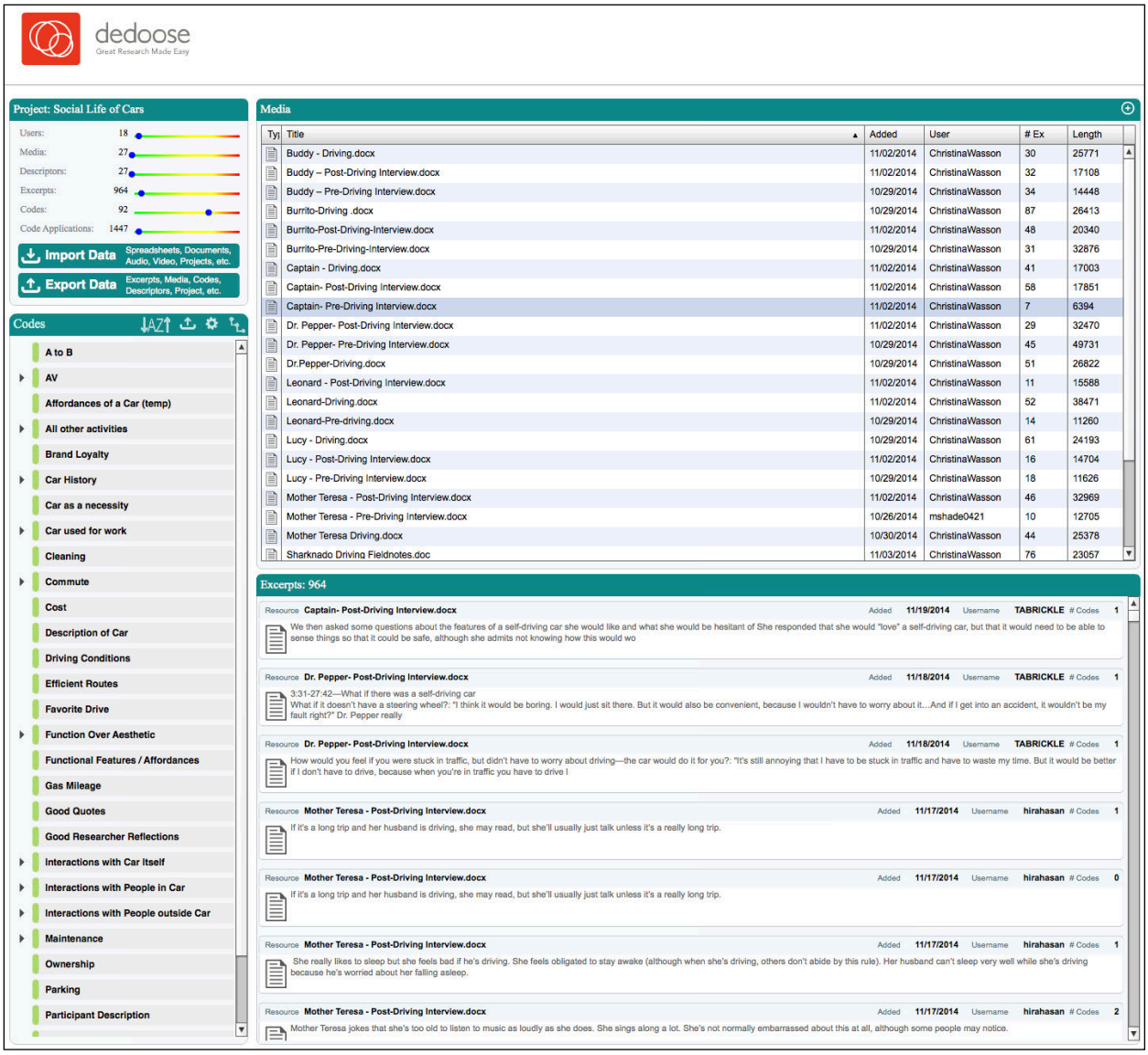


Figure 2.1. Sample Screen Shot of Dedoose

Throughout this analysis process, we also considered potential design or social implications informed by our research findings. The design students in our class were especially helpful in this regard, as they were able to visually conceptualize these implications in a way that the anthropology students could not. It has been a true collaborative effort.

Study Participants

Figure 2.2 provides a summary of our nine study participants.

Pseudonym	Age	Gender	Race/ Ethnicity	Job	Type of Car
Burrito	21	M	Saudi Arabian	Undergraduate student	2005 Nissan Altima
Mother Teresa	50s	F	White	Church camp administrator	2001 Infiniti I30
Leonard	28	M	White	Physicist	2006 Dodge Stratus
Dr. Pepper	32	F	Asian	Photo editor	2011 Lexus RX 350
Lucy	41	F	White	Home school mom	2007 Toyota Sienna
Sherlock	58	M	White	Criminal investigations	2014 Ford Mustang convertible
Buddy	21	M	White	Undergraduate student	2001 Toyota Corolla
Captain	25	F	Mixed white	Undergraduate student and intern at Funimation	2002 Hyundai Accent
Sharknado	22	M	Filipino	Graduate student	2001 Honda Accord

Figure 2.2. Study Participants

Our ethnographic research approach revealed the complex, multifaceted social networks within which the use of the car was embedded for each study participant. Figures 2.3, 2.4, and 2.5 provide three examples of these physical, virtual, and sometimes invisible passengers. The different social relationships related to car use will be explored further in coming chapters.

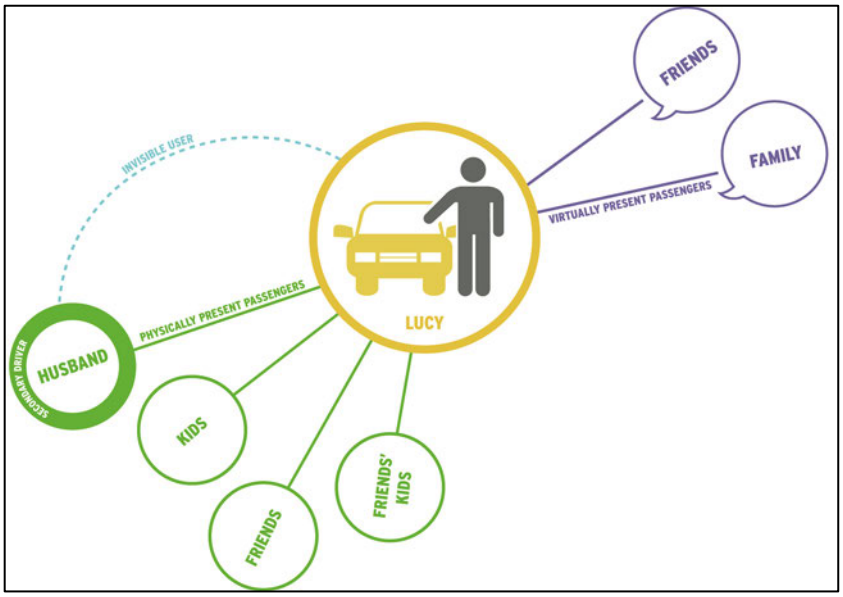


Figure 2.3. Social Network for Lucy

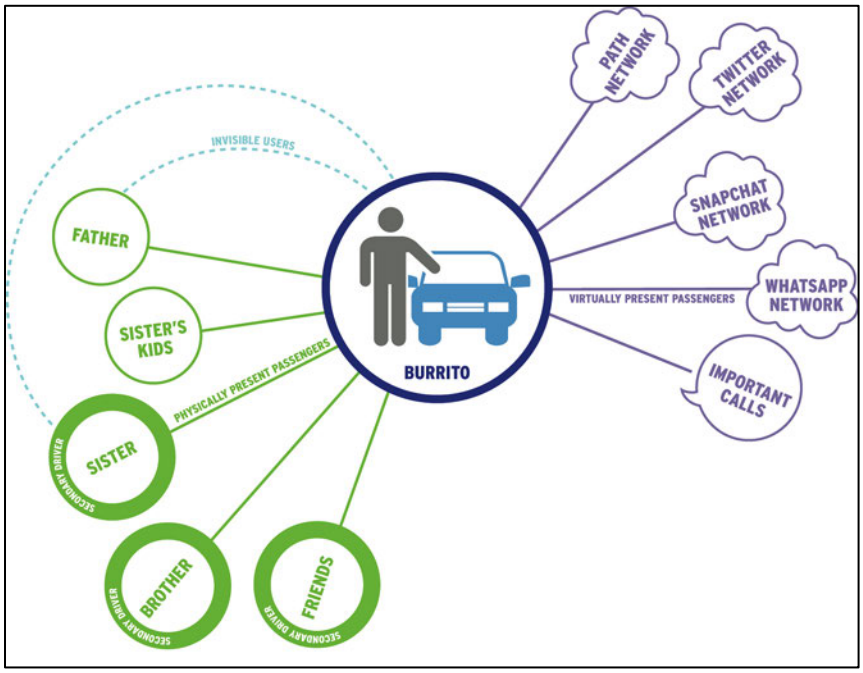


Figure 2.4. Social Network for Burrito

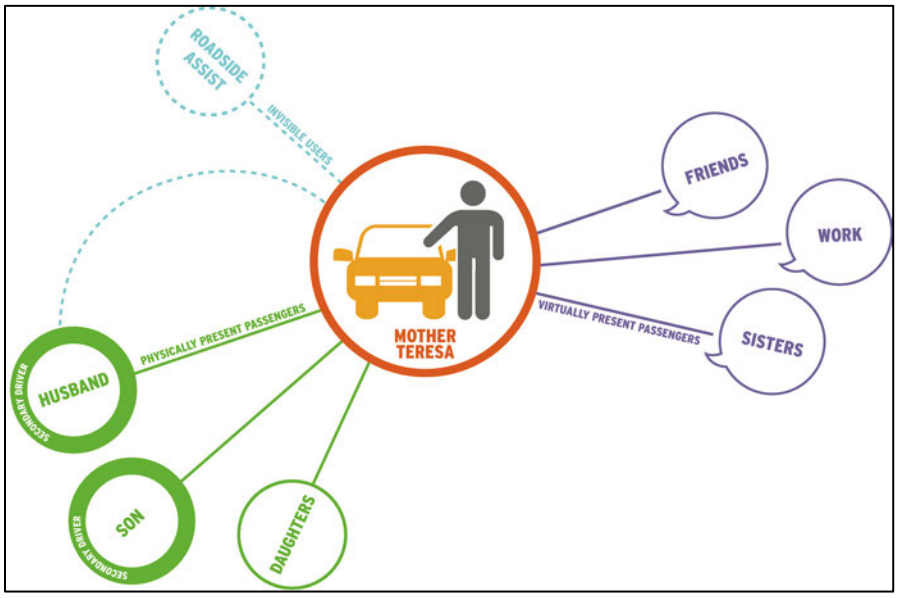


Figure 2.5. Social Network for Mother Teresa

Limitations

In our final days of analysis and report preparation, we took the time to discuss the limitations and problems that we encountered during our research. In terms of our methodology, we agreed that conducting a second or even third driving observation would have been incredibly beneficial, but our timeline simply did not allow for such extensive data collection. It also appeared that participants were

most comfortable and forthcoming when interviewed in their home. And while our convenience sampling did result in a surprisingly diverse group of study participants, their vehicles were somewhat less so. Six of the vehicles were sedans; four mid-size and two compact. Representing the rest of the vehicular world were one crossover, one minivan, and one sports car. Trucks and SUVs are noticeably absent. In the future, researchers should conduct multiple driving observations with a wider range of participants and vehicles.

Driving Behaviors

3. Attending to the Environment and People Outside of the Car

Andy Pottkotter and Cate Ferman

Research Findings

Every car has an *interior* and an *exterior*, separated by ponderable walls. Every car also has an *inside* and an *outside*, separated by imponderable *boundaries*. These boundaries demarcate a culturally meaningful space. They divide the car from its environment, encapsulate everything the car contains, and practically segregate the driver from the multitude outside. They are social, rather than physical, and therefore structure social interactions on the road.

In this chapter, we ask:

- What aspects of the car's outside environment do drivers consider important for driving?
- How do drivers communicate with people outside of the car?
- What kinds of communication do (or should) the car's boundaries prevent?

The answers to these questions bear on the future design of automated vehicles, for their designers have the opportunity to redraw the boundaries of the car, the better to integrate the new technology to its consumers' culture.

Attending to the Road

Road Conditions: Rhythmic Shifts of Attention

Although all study participants attended carefully to road conditions—conscientiously obeyed the rules of the road—on many occasions, we observed that their attentiveness was inconstant, alternately wavering, fixating, and wavering again. Driving, we discovered, was a rhythmic experience, involving shifts of focus—now intense, absorbed in the swarming allegro outside; now mild, diffused in the tranquil adagio inside. The former was stressful, often demanding that drivers actively "tune out" what was happening inside, whereas the latter was relaxed, permitting drivers to divide their attention as they desired. Figure 3.1 illustrates this rhythmic flux.

The rules of the road permitted these shifts and, from time to time, even encouraged them. Getting into the rightmost lane, for instance, relieved drivers from the stress of road conditions—the rightmost lane required less attentiveness, whereas the other lanes required vigilance, keen and deliberate mindfulness of road conditions. In Sherlock's words:

> If I'm going to drive and be on the phone, that's when I'm going to just- kind of- stay in the right-hand lane and go with the flow of traffic. Then, the only thing I really have to worry about is how fast the car in front of me is going; so, if it stops [I know to stop]. Even with "hands free," you can get pretty well distracted. Your mind wanders and stuff like that.

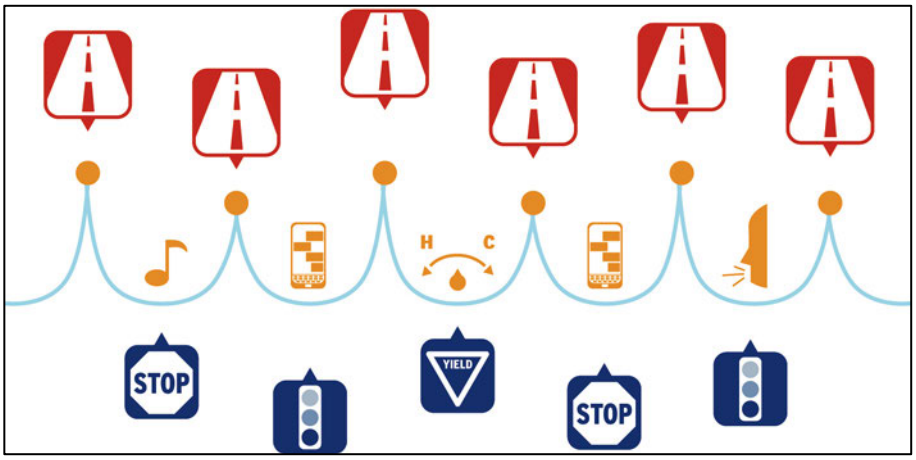


Figure 3.1. The Rhythms of Driving

Stop lights also supplied moments of pause, when drivers could cease to engage with road conditions and, instead, give themselves to more leisurely activities, such as social interaction with passengers. As Mother Teresa described her behavior at a stop light:

> I try to be engaged and focused and pay attention when I'm driving; though, when that stops, it [provides] a- sort of- relaxed moment, so you don't have to stay *on* all the time. I think that's helpful not to burn out- be frazzled or whatever- because, driving (depending on the traffic) can be exhausting.

And, as Sharknado stated about the proper time to fiddle with his cell phone:

> I definitely try to avoid [using my phone while driving]. I'm a huge proponent of, like, *no texting while driving*. I'm a little bit more lenient with, like, quickly glancing and reading; but, I'm not the kind of guy who will use his elbows. But, when I'm stopped—yes. […] I treat it like music. It keeps me up.... Whenever I'm completely stopped or in very slow motion...that's when I read. Sometimes I respond, but I never—like—respond right away. I wait for the right time.

Obstacles in the Road

The drivers in our study talked about needing to deal with obstacles in the road such as discarded debris, construction sites, bumps, and potholes. Drivers considered the presence of obstacles the principal reason cars should have good visibility, and they valued cars that did. Good visibility encouraged good driving. As Dr. Pepper commented, complaining about her car's poor visibility:

> I'm short; so, I'm always [obstructed] by the steering wheel. That thing around the windshield—the frame—I wish I could see around that. Even the Japanese car—I don't know what the model was—the cubic one—it doesn't have a frame on the backside, on the corner. I think that would help. If all the cars [around me were visible]—if the frame part were clear—if [I could see] everywhere, not blocking my view from the frame...[I would see more easily] here and there, whenever I look around.

Traffic

Traffic was another challenge drivers in our study faced. Study participants consistently maintained that "going with the flow" was the sensible response to traffic. More than one even suggested that going over the posted speed limit, if one nonetheless went with flow of traffic, was more prudent than observing the

letter of the law. Buddy believed in this principle so adamantly that he cited it in his defense regarding what he considered an unjust traffic ticket. Mother Teresa put a number to the principle, saying that three to five miles per hour over the limit was acceptable, but that ten to fifteen was not. Under normal circumstances, then, drivers did not consider traffic inherently problematic; traffic even served a regulatory function, informing drivers how to behave via the perception that traffic was behaving in such-and-such a manner. Accordingly, our study participants apparently did not regard the rules of the road as authoritarian—they treated the rules as being socially constructed, inasmuch as what counted for obedience to them depended on a standard set *by consensus*, presumably relative to local road conditions.

Drivers Notice Other Drivers When The Latter Cause Problems

When drivers in our study noticed other drivers, they did so almost always because the latter engaged in actions that they regarded negatively, as illustrated in Figure 3.2.

Every reference our study participants made to "other drivers" portrayed them as problematic, summarized cogently in the common epithet "idiot." "People drive like idiots," Sherlock said. "People don't know what they're doing," Captain declaimed. The word "idiot" signifies the character of other drivers' emergence: only when a problem occurs do drivers come to perceive traffic as made up of individuals. Before they become "idiots," other drivers are simply *traffic*, expected to behave in a particular way.

Attending to People Outside of the Car: Four Communication Channels between Inside and Outside

While the boundaries of the car make some kinds of communication between drivers and people outside difficult, drivers nonetheless do communicate regularly. We identified four main channels of communication in our study:

- Direct communication by drivers
- Use of communication tools built into car
- Communicative movements of the car
- Imaginary conversations

In our study, we mainly observed drivers communicating with other drivers. We observed few instances of drivers interacting with pedestrians or bicyclists.

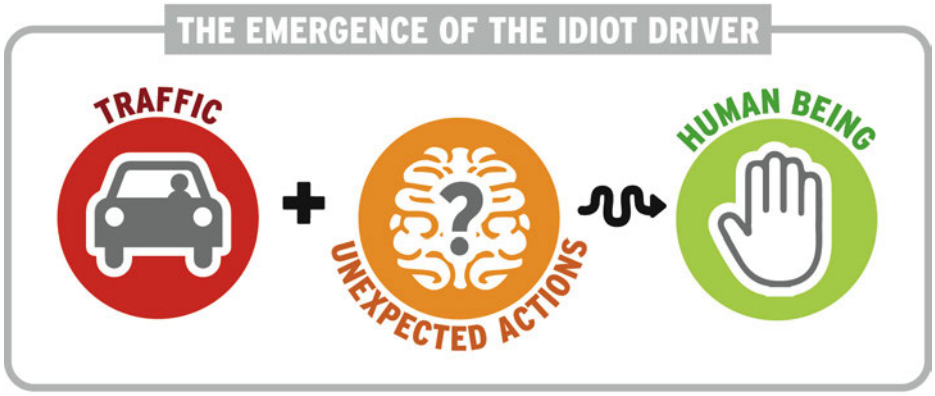


Figure 3.2. The Emergence of the "Idiot Driver"

Direct Communication by Drivers

Drivers in our study communicated directly with other drivers by making visible bodily gestures. For instance, Burrito gave another driver *the evil eye* to express disapproval at her neglect of the rules of the road. In a second example, Buddy criticized other drivers who did not reciprocate a kindness on his part by *waving*, a common means of expressing appreciation.

Our study participants seemed to reserve this kind of direct communication for complex messages because it afforded the most nuanced meanings.

Use of Communication Tools Built into Car

Drivers also employed devices supplied in the car, such as the horn and blinkers, to communicate with other drivers. They used these communication tools both for the "standard" reasons as well as for more complex messages—though not so complex as those communicated by gaze or gesture.

For example, Sherlock activated the blinker to communicate his intent to turn; indeed, when he once activated the blinker too early, he shut it off the moment he realized his mistake. We noted, however, that drivers seemed to use their blinkers a bit haphazardly. They sometimes forgot to activate them entirely and, other times, allowed other acts (such as lighting a cigarette) to distract them and leave their blinkers going past the meaningful moment. In a second example, Mother Teresa posited two functions for the horn: as a kind of spur, snapping another driver to attention, and as a kind of paddle, chastising another driver for bad driving.

Messages sent by the horn and blinkers, therefore, seemed typically simple, being for the most part declarations and commands requiring forcefulness but little nuance. These sorts of messages, far and away, were the most frequently sent and received by our study participants.

Mother Teresa also indicated a more nuanced use of the horn, which she claimed to employ on occasion. Sometimes, when parked outside the residence of a passenger-to-be, she would honk to call that person out—a statement that "I'm here!" but adding "so, come on!" rather than "so, get out of the way!"

Communicative Movements of the Car

The drivers in our study also communicated with other drivers by placing their cars in certain positions vis-à-vis other cars – kind of like the body language of the car.

For instance, Mother Teresa brought her car uncomfortably close to the car in front of her as a signal to "move over." Although she could have sent this same message using the horn, tailgating is considered more polite than honking in Texas.

Mother Teresa also wished she could use the horn to send positive messages, to "make a connection" with someone else on the road, but recognized that honking is often inadequate for that purpose. There are currently few ways for drivers to initiate an overture of kindness or an invitation to comradeship.

Imaginary Conversations

Finally, we observed our study participants having imaginary conversations with other people whom they saw outside the car. These episodes provided clues into the kinds of communications that drivers would like to be able to have. For instance, Dr. Pepper addressed a group of children playing in the street, commanding them to "watch out!" but made no practical effort to be actually heard. Nor did the researchers seem to be her intended audience. In a second example, Buddy satirically responded to a bumper sticker as if he were addressing another driver, thereby demonstrating its absurdity for the

researchers. The phrase "baby on board," he argued, was, for all practical purposes, a useless declaration, since any rational person would be unaffected by its pathetic rhetoric.

Unwanted Communications

In our study, some research participants talked about receiving unwanted communications from other drivers. They expressed their desires for stronger barriers between themselves and those outside the car, and the ability to control their accessibility. For instance, Captain said:

> I would really like to have tinted windows because, on occasion, I've had people, you know, look at me and wave at me and, it's just- kind of- uncomfortable. Kind of uncomfortable, especially when you are at a stop light and someone's all [stares conspicuously]. It doesn't happen often; but... it's happened more than I'd like to admit. It makes me kind of, close off my peripherals when I'm driving.

Captain's reaction lucidly demonstrates that drivers may wish to control their availability for communication. Lacking such control, communication initiated by others outside the car may feel at best like an imposition and at worst like an affront.

Implications

Maintain the Rhythms of Driving

Since automated vehicles will undoubtedly reduce the number of circumstances requiring attentiveness to the road, where drivers may want to direct their attention at any given time becomes an open question. We cannot assume that drivers will simply give more attention to passengers or their cell phones, although these are certainly valid options. The rhythms of driving are meaningful to drivers—without a steering wheel, Dr. Pepper suggested, driving would be "boring." Perhaps automated vehicles could provide drivers a new means of interacting with the environment outside the car, such as route-planning or manually updating a central database of road conditions, possibly with more detailed information than the system itself gathers—something to keep drivers engaged with the road, encouraging participation in the automated vehicle experience.

Add New Communication Tools Built into the Car

The overwhelming majority of messages we witnessed study participants send to other drivers utilized communication tools built into the car, such as the horn and blinkers. These messages were generally simple, such as "I will now turn left." However, the drivers in our study wished they could communicate more complex messages to people outside of the car. Since automated vehicles will likely reduce drivers' needs for built-in communication tools as they are currently used, new features might expand the potential messages transmittable by them—for instance, installing a second "approval horn" such as the one depicted in Figure 3.3. Furthermore, new features might give adjacent drivers the option to open up a communication channel on their cellphones or computers. However, drivers need privacy controls too. While some extroverted drivers might enjoy meeting new people, many drivers might want to be left alone. Opening channels with pedestrians or bicyclists might also serve some drivers' interests.

Fig. 3.3. Dial for a Graduated Horn

Shrink the Bubble Around the Car

In our study, we found that drivers seemed to imagine a personal bubble around the car, an area of space that they did not want other cars to violate while they were moving. In part, safety issues occasioned this imagination, since stopping in an emergency takes some distance. At the same time, drivers seemed to have internalized this image of a bubble, practically creating it a social boundary, similarly to how people in face-to-face encounters maintain a bubble of space around themselves.

A civic benefit attending the proliferation of automated vehicles is the ability to reorchestrate travel, shrinking the minimum safe distance between cars. To realize this benefit, however, drivers must learn to feel comfortable in a smaller bubble. At first, perhaps, automated vehicles should follow each other at unnecessary distances, which can shrink over time as people come to accept automation and internalize the harmlessness of following closely at high speeds.

Prevent Unwanted Communications

Since some of our study participants expressed concerns about receiving unwanted communications from other drivers, automated vehicles might add features to manage privacy better. For example, they might include windows with selectable degrees of tint, whereof Figure 3.4 illustrates a possible user interface. Including such a feature would enable drivers to remove the tint and enjoy a panoramic view when going on a scenic nature drive (see Chapter 9 for more on the value drivers place on scenery). When drivers want privacy, they should be capable of it; but, for their safety and the safety of others, they should not be able to close themselves off entirely.

Fig. 3.4. Dashboard Interface with Window Tint Opacity Slider

4. Attending to People in the Car

Amanda Whatley and Cate Ferman

Research Findings

The car has long been a place of social interaction, but necessary driving tasks affect the way a conversation is held and the interactions between the driver and passengers. The driver must pay close attention to the road, driving conditions, and other vehicles, while simultaneously navigating the community connections inside the car. Many of our study participants valued sociality in the car; their favorite drives were often the most social, like road trips. Some participants identified driving as precious time to spend with their loved ones, children and spouse, or a chance to connect with friends.

Many studies have shown that when people engage in social interactions, at least in mainstream America, they usually turn their bodies so they are all facing one another. This facilitates eye contact and allows people to observe each others' body language. The arrangement of seats in a car prevents this kind of circle from forming and makes eye contact more difficult. It therefore creates challenges for people when they instinctively try to use familiar kinds of body language to show they are paying attention to each other.

In our research, we found that the driver adopts specific modified behaviors to both ensure safety and meet cultural norms regarding conversations. It seems apparent from the videos captured for this project, that there is a sliding scale that drivers navigate which indicates shifting patterns in the apparent weight given to attentive driving and sending physical social signals to passengers inside the vehicle. Of course the very "display" of attentive driving is itself a social signal. The apparent norm within the videos is for the driver of a given vehicle to also "drive" the conversation. In moments of increased risk, such as at intersections and merging onto an interstate, social interaction decreases, while focused, attentive driving increases. On one end of the scale, one can see a very rigid posture, with two hands on the steering wheel and the driver's head swiveling for views of traffic from other windows or mirrors. This is contrasted with a more relaxed posture, frequent hand gestures during conversation, and direct looks at passengers to the driver's immediate right.

Talking while Driving: The Social Conditions of Fieldwork

None of the drivers were alone during the driving observation, since they were accompanied by two researchers. Even though the researchers did not purposefully ask questions of the driver in an effort to ensure safety, it is natural that conversation did take place during the drive. Acknowledging the person talking – whether the researcher or another passenger – took varying forms for each driver, but it is important to note that every driver completed either a symbolic gesture towards the speaker, made direct eye contact using the rear-view mirror, or even turned their entire body around to socialize with the passenger(s). For the purposes of safety, the researchers made an effort to observe the drivers without launching into the more focused interview questions that are seen in the pre and post driving videos. Awareness of this effort on the part of the researcher, and participant if so informed of the deliberate effort, may have influenced behavior somewhat. Still, it seems apparent that drivers who began with a very sharp focus on attentive driving, and limited physical social signals, relaxed and increased physical social signals over time.

Symbolic Gestures That Substitute for Actual Eye Contact

As humans we rely heavily on eye contact not only to impart worth to the conversation, symbolically assuring the speaker we are, in fact, paying attention to what they are saying, but we also rely heavily on non-verbal cues to denote meaning. When drivers were unable to make direct eye contact with a speaker, they substituted that action for a symbolic glance towards the passenger, as illustrated in Figure 4.1. The study participant Lucy displayed a desire to make eye contact during conversation, but was careful not to lose focus on her attention to driving; therefore she was relegated to gesturing towards the speaker with either a slight head turn or an almost bobbing back motion to denote her intentions. Captain was also concerned about vehicle safety; a sentiment she expressed throughout the research process. During her drive she made a slight head turn towards the passenger while talking to denote attention, but did not actually turn away from looking at the road. While the vehicle is in motion, Captain never makes direct eye contact; she expressed sociality through symbolic nods or hand waves.

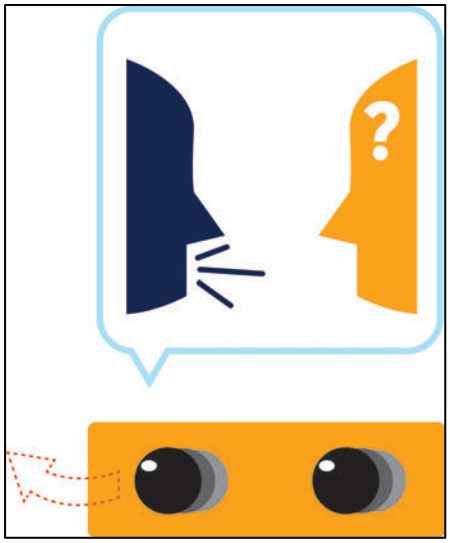


Figure 4.1. Symbolic Gestures That Substitute for Eye Contact

High levels of focused attention, such as driving, interfere with our natural desire to look at those with whom we are conversing. This is best exemplified with the participant Sharknado.

> The researcher, Stephen, is conversing with Sharknado, but when the participant fails to hear Stephen he asks him "What's up?" while simultaneously roving his eyes towards the back seat, but not actually turning his body nor really taking his eyes of the road.

Even though Sharknado asked for clarification, none of his moves physically ensured that he would hear better; however he had to make that symbolic gesture towards the researcher.

Other participants who made similar symbolic motions towards the speaker include:

- Leonard
- Sharknado
- Dr. Pepper
- Mother Teresa
- Buddy

Direct Eye Contact

There were a number times when the driver of a given vehicle gave a direct look at the passenger in the front seat. This contrasts with forward-facing, more distant body language, or the "half-right" quick and symbolic glance. Direct eye contact seemed to indicate the driver's desire to convey either their own conviction on a particular topic, and/or assess the facial reaction of the passenger. Burrito used this method of communication when another method failed:

> Burrito uses his rearview mirror to make eye contact with Heather, positioned in the backseat, when she fails to understand his answer he turns his head all the way around to face her and repeats his answer that "ya", they are headed back home.

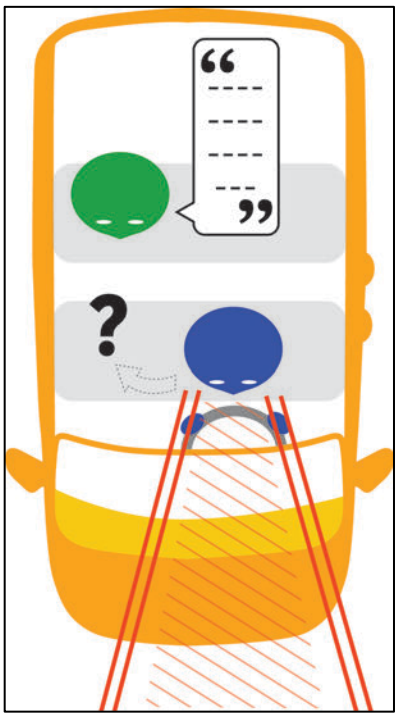
At an earlier point in the video while driving in the DMV parking lot, Burrito took this action again, turning his body and glancing toward the researcher in the passenger seat, Marwah; he asked her whether or not she would like to stop and get something to eat. This was much more than the symbolic nod discussed earlier. Here the driver truly desired eye contact while asking a question and took his eyes off the road to complete the action.

Picking up on non-verbal cues is integral to the trajectory of a conversation, and can inform the speaker about adjustments that may be required for continuing the conversation. In our research, direct looks seemed more frequent while the vehicle was stopped for all drivers, though some drivers appeared to give frequent direct looks throughout the driving portion of their videos.This method was mostly utilized when the driver was unable to hear the researcher clearly, or took the opportunity to have a quick conversation while approaching a stop. Even the most cautious of the participants, Captain, used a red light as an opportunity to look at her researcher.

The participant Buddy was quite familiar with his researcher, and make frequent eye contact throughout the drive. Buddy would glance directly at the researcher in the passenger seat whether he was actively driving or at a stop. This is not to say that Buddy endangered the researchers at any time, he was very aware of his surroundings and drove comfortably. For Buddy eye contact while conversing was simply just part of the driving process.

Other participants who made direct eye contact include:

- Leonard
- Sherlock
- Dr. Pepper
- Lucy
- Mother Teresa
- Captain



Eye Contact Mediated by the Rear View Mirror

The rear view mirror is integral to safety, parking, changing lanes, and other necessary driving features; however this is not its only function. The rear view mirror has emerged as a tool for maintaining social connections in the car. Probably not intentional in its initial design, users have adapted it to their own purposes. To facilitate social interactions many drivers use the rearview mirror to make eye contact with passengers in the back instead of turning around, as illustrated in Figure 4.2. The participant Leonard used his rearview mirror to make eye contact with his researcher while stuck in traffic*;* Mother Teresa glanced into the rearview mirror to look at researcher Molly as she asked Mother Teresa a question.

Additionally, in the Lucy driving video, we saw the addition of a “drop-down” convex mirror built into a minivan which increased rearward internal visibility of the vehicle, and acted as an indispensable tool for Lucy to monitor her five-year-old son, who was seated just behind the front passenger seat.

Figure 4.2. Eye Contact Mediated by the Rear View Mirror
In our observations, the move to initiate eye contact looked incredibly instinctual - as if the driver did it without thought, or that they were waiting for an opportunity to make that all important connection.

Additional research participants who used this method include:

- Dr. Pepper
- Sherlock
- Burrito
- Sharknado
- Captain

This further defined the car as a social space. It was a place of conversation and social interaction.

Attending to the 'Invisible User'

Some of the study participants had invisible users present in the car, even if their body was not there physically. An example of this was a driver who carried food in their vehicle to give to someone who is homeless. Although not physically present in the vehicle, the homeless person was a user of the vehicle; the driver had planned for this interaction. The driver was attending to a person whom they might not see that day, but accounted for nonetheless.

Another instance of this social connection in our research involved Sharknado. During his post-driving interview he mentioned that the rosary in his car was a gift from his mother. All the cars in the family had rosaries – and he even touched it sometimes to relieve anxiety when someone cuts him off, a habit developed from observing his mom. This showed that even though Sharknado's mom was not physically in the car with him, he still maintained a social interaction with her through the use of the rosary. She was an invisible user in the car and managing the rosary around his rear-view mirror was attending to people "in the car". A lack of physical presence did not equal a lack of social connection involving the car. A second example was provided by Mother Teresa. Her husband reserved the garage for her car and she described the garage as the "place of honor" that was gifted to her by her husband. Even though her husband was not physically inside the car, his relationship with Mother Teresa shaped her navigation of the car.

Implications

Most of the drivers stated that their favorite drive was one taken with friends or family, the social drive. Leonard saw the long drive as a chance to spend time with his wife and talk. In an AV setting the opportunity arises to have less conventional seating arrangements and although this itself may aid conversations, outside noises do impose themselves into vehicles making it difficult for people not seated directly next to each other to converse. It would be beneficial to create an acoustically enhanced car so that passengers and 'drivers' in varying seating arrangements would be able to hear each other clearly. Because people will have more freedom to move about the cabin this addition could be highly beneficial; as can be seen through the data, people highly desire to look at each other when speaking, and people will naturally desire to seat themselves where they can hold a conversation that includes the sharing and understanding of non-verbal cues. Figure 4.3. shows seating arrangements displaying the social interactions possible in an automated vehicle.

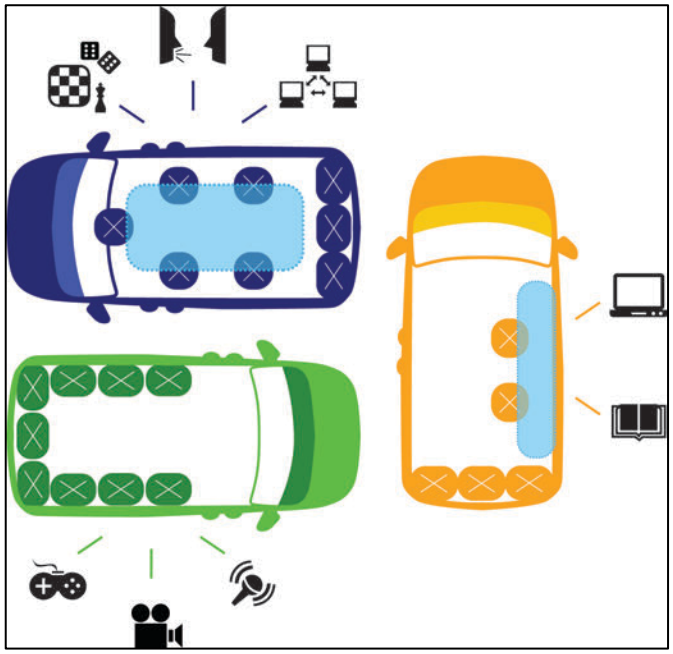


Figure 4.3. Multiple Seating Arrangements

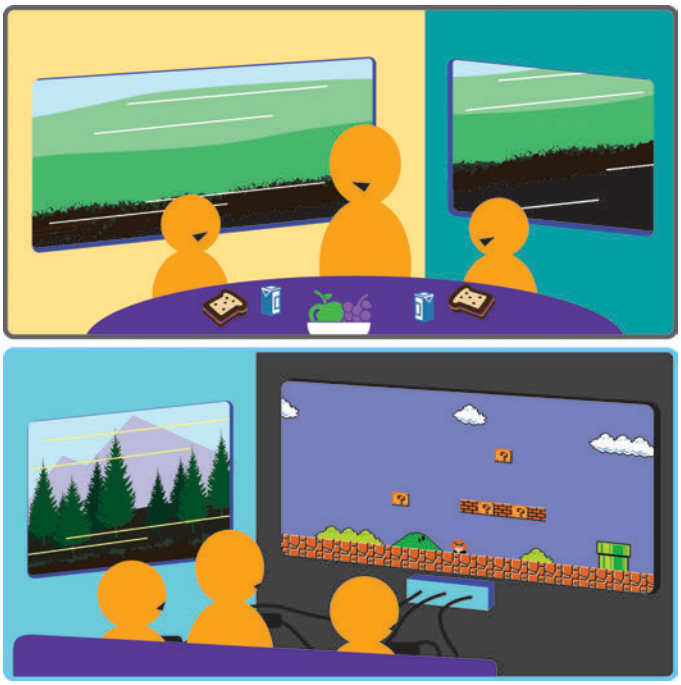


Figure 4.4. Car Interiors that Support Social Activities

A car in which there is no need for a driver could simply become a new space to "hang out". This creation of a new social space means customization will be essential, but this is not just in reference to car color or leather seats. People riding in AVs will have the chance to socialize as they would anywhere and in any way. Screens, hook-ups for gaming systems, USB ports for plug and play will be beneficial in supporting the car as a social space, a relaxing and fun environment where friends would want to spend time

together. The "social" drive could truly be social time spent similarly as it would be in one's living room – the car as an extension of the home social space.

A parent could use this space to spend time with their kids going over homework after school; he or she could even prepare a snack in the car. The option to include a small fridge and a pull down table could make the afternoon rush easier to manage. Figure 4.4. illustrates different social uses of the car, including children eating snacks after school (top) and passengers enjoying video games during the drive (bottom).

Customization would also allow the driver to attend to those invisible users who may not be physically present in the car but still maintain an impact on the driver. An example would be a small pantry to give our food to homeless while at a stop light.

A constraint to this model of a mobile social space would be to consider those who are heavily affect by motion sickness. Many people who suffer from this malady would still need the option to face forward and be able to clearly see the direction in which they are headed to aide in their relief. Unfortunately this group of individuals may not be able to fully utilize nor experience AV's in the same way other populations will.

Every driver is going to want to use the time they used to spend on driving in a different way; customizable cabs would make it possible for every consumer to have the car they want, but also need.

5. Attending to People Who Are Virtually Present

Luis Machado, Marwah Halwani, and Jung Kim

Research Findings

In Brief

- All our participants used their cell phones in their vehicles.
    - Some only while stopped at a stoplight or in heavy traffic, others at any time.
- There was a range from Buddy who claimed to be unaffected by using his cellphone while driving, to Leonard who refused to use his cellphone entirely, with the other seven participants somewhere in between.
- All drivers had justifications and reasons for why and how they used their cellphones while driving:
    - They provided a distraction from the monotony of driving
    - They provided access to those who they only infrequently communicate with
    - They made the individual accessible in case of emergencies or work situations where information needed to be communicated
    - They provided opportunities to share the experience of the drive (amusing signs, attractive or appealing sights) with their social sphere
- There was a disconnect between the fear and caution of driving our study participants expressed and their use of cellphones as they drove.

Exploring the Findings

Analyzing our participants' driving behaviors revealed that all participants used their cell phones in their vehicles. Some of them used their cellular devices to text, make and receive calls, or access apps while driving. Some claimed reticence to use their phone at all while driving, using them only when they were stopped at a stoplight or in heavy traffic. All the participants had justifications and reasons for why and how they used their cellphones while they drove. One of the reasons for having used cellular devices in the vehicles was to distract from the monotony of driving. Another reason was that making calls while driving allowed access to those who they only infrequently communicated with. Other causes were to make the individual accessible in case of emergencies or work situations where information needed to be communicated, and to share the experience of the drive (amusing signs, attractive or appealing sights) with their social sphere.

Our analysis revealed that there was a range of comfort among our participants in interacting with others through their cellular devices. We also found that there was a disconnect between the fear and caution of driving the participants expressed and their use of cellphones as they drove. The range went from Buddy, who comfortably used his cellphone constantly while driving; to Leonard, who refused to handle his phone at all while driving, though for work purposes he did accept critical calls (once or twice a month at most). Between those two extremes, our seven other participants had various degrees of ease using their cellphones to text, make and receive calls, and access apps while driving. All of the participants had

reasons and justifications for why it was useful, acceptable or necessary for them to handle their phones on the occasions when they did. At the same time, all of the participants seemed concerned about the danger of driving distracted and identified themselves as careful or safe drivers. The disconnect between fears and action prompted further scrutiny of driving behaviors resulting in an accounting of the rules each participant had for cellphone use while driving. See Figure 5.1 for a list of each study participant's personal rules and use of cellphones.

Study Participant	Personal Rules for Cellphone Use in Car	Functions/ Apps Used
Buddy	Will text when "feels safe" to do so. Not when merging lanes on the highway, but on long stretches of road. Or when stopped at a stop light or traffic light.	Text messaging
Burrito	None stated	WhatsApp Text messaging Phone calls
Captain	Would keep her phone in her bag in the backseat so as to not use it. But would text when stopped at a traffic light or other stop and send very brief texts when necessary and to break the monotony.	Text messaging
Dr, Pepper	Does not use her phone, but will check it when she is stopped to see if she has a text message and can respond quickly.	Text messaging
Leonard	Phone is used only to receive calls from work, and those very rarely.	Phone calls
Lucy	Receives calls, but isn't likely to make them. Does not text and tries to handle her phone as little as possible.	Phone calls
Mother Teresa	No texting, no handling the phone except to make calls.	Phone calls
Sharknado	Uses speakerphone to talk to his social circle while driving. Otherwise, only uses his phone when stopped or in very slow moving traffic.	Snapchat Text messaging Phone calls
Sherlock	When his phone is configured through Bluetooth, will answer phone calls and drive. As his phone is currently not synced, he pulls over to take calls, or drives on the far right side in case his mind wanders. Does not text.	Phone calls

Figure 5.1. Study Participants' Rules for Cellphone Use

From the patterns revealed after reviewing all of the field notes, the issues with interacting with those virtually present exist on several levels. Texting is illegal in some cities in Texas, including the main site of our study, so there exists a potential risk for the driver every time they text in their car should they be spotted by the police or cameras detecting such actions. Further, well documented studies have conclusively shown that even a one second distraction for the driver can be enough to cause accidents, and cellphone use rarely lasts so little. Both of these facts seemed to be generally understood by study participants, and yet the use of cellphones in cars was an ongoing and a largely dismissed part of their driving habits. This is evidenced by the fact that seven participants said they used their phones to socialize while driving, while two participants used theirs only for emergency situation or to receive calls. The implication seemed to be that while they had their justifications, all of our participants had a need or dependence on interacting with the virtual space accessible to them through their phone.

The disconnect between the behaviors and attitudes of our drivers was further evidenced in specific examples. Buddy said he didn't think cellphone use affected his driving, yet he put the phone aside while changing lanes. It seemed that Buddy was aware that splitting attention between the cellphone and trying to change lanes was impractical if not outright dangerous, yet he still professed to be relaxed about his use of a cellphone. Similarly, while Captain professed discomfort at using a cellphone while driving, and usually kept her phone in the back seat, she nonetheless said that she sometimes took calls when there was heavy traffic and she was really bored.

Itself a pattern to note, several of the participants commented on engaging with their phones only during traffic situations, while stopped, or other such situations which they seemed to view as very low risk. Boredom and monotony were then punctuated by moments when they could access their phone and by extension reach to their social sphere for rapid exchanges. After examining several instances of participant driving behavior and mobile phone use, we observed that most participants took advantage of time spent in the car to catch up on their social life. Mobile phone texting, making and receiving calls, and accessing phone apps while in the car thus allows people to connect. It wasn't clear if their desire to connect was an issue only of attention and focus; that would suggest that slow traffic situations require little attention and so the mind wanders to their social life. Alternatively, it could be that they had a compulsive desire to not be alone (while isolated in a vehicle surrounded by others), and so reaching out or at least being aware that one could reach out was somehow soothing.

Implications

A number of tools could be added to an AV to facilitate and enhance virtual interactions between people in the car and friends/family who are not physically present. We note that The passenger will likely be in a position to enjoy as much access as the driver to the functions that the car will have as it progresses closer to being a fully AV. This means in most cases where "the driver" is used, the passenger should have access to the same technology.

Several considerations should be kept in mind when implementing the ideas described below. First of all, in emergency situations, there will need to be a way to help the driver switch quickly from social activities to a focus on driving. Secondly, different users will have different communication preferences, so there should be a high level of customizability. Perhaps there could be a selection of modular parts that each user would choose from, based on their preferred activities. Thirdly, since many people have concerns about electronic surveillance, these features should all include transparent on and off options.

Cellphone Integrated with Car Interface

To replace the requirement for a phone-in-hands driving experience, we suggest a dock that facilitates text-to-speech. A completely AV that requires no human interaction with the driving process would allow for the full ease of access to the phone and texting, or apps. Also, for lower levels of AV, there could be an interface between the phone and the car that permits the driver to engage with the road and their apps at the same time. In addition to the previous tool, and applicable in the transition stages before fully AV are available, a possible extension and adaptation of cruise control could be created that would keep the vehicle on the road for a predetermined amount of time or distance (on a straight highway for instance, corroborated by GPS), giving the user time to interact with their social sphere.

Cameras

Cameras could be made available to the driver so that the experiences of the driver (internal and external to the car) could be shared and communicated, as shown in Figure 5.2. The external cameras could simply be at the four cardinal points of the car, allowing picture capture of one or several at the same time, and then these could be bundled and sent through social media or saved onto the car's memory or

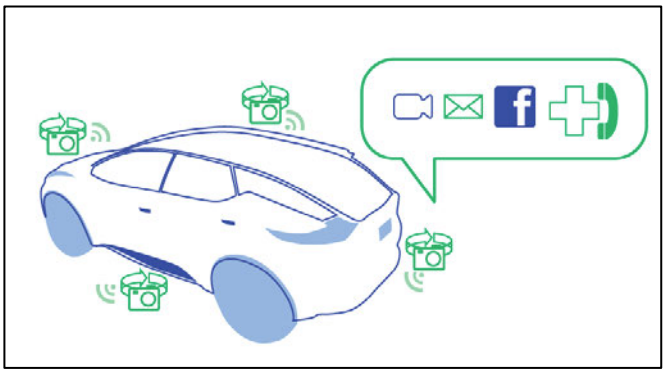


Figure 5.2. AV with Image Sharing

onto a cellphone or other removable media device connected to the car. The external cameras could also be mounted at multiple points around the car from the front to the sides. It is assumed that front and side facing cameras would be the easiest for the driver to interact with, as these would not affect as great a shift in perspective as a rear-facing camera would.

Considerations would need to be made for motion-sick drivers and passengers. Whether these include some form of inertial dampeners, affected air pressure sealant or other solutions, it will be important to minimize the amount of motion that drivers and passengers who are prone to motion sickness would experience.

On the subject of cameras both internal and external, they could have swivel functions individually placed so that the driver could take control of one and angle a picture as appropriate before taking a picture. A simple D-pad attached to the steering wheel is one option for this. Also, in an AV, touch screens embedded throughout the car could be toggled with the standard touch, zoom, and twist to set up the proper picture. The cameras could be passively monitoring the car externally and could make a note on an ongoing video track by a command from the driver "Remember this/Camera On/ Toggle Record" and stopped in the same way. Photos/recordings could then be uploaded, dumped, sent, or stored to social media, a removable memory device, or some form of online storage, as illustrated in Figure 5.2.
The internal cameras could be focused on the driver and passenger seats and optionally in the back seat. There should be some requirements for these internal cameras, such as some form of lens or cover to appease the security conscious and if not, they need to be entirely removable. Their location could also be customizable to appease the more technologically inclined who could set them in any position they wanted. Moreover, these internal cameras could be coordinated in much the same way as the external cameras discussed above so that the driver could engage with them.

Audio Interface

Figure 5.3. Speech to Media Communication

AVs could include an audio interface that allowed the driver to engage with apps, text messages and phone calls without removing their hands from the wheel, as shown in Figure 5.3. Fortunately, this technology already exists; it just needs to be improved to allow the driver more flexibility in available commands and possible responses. For examples, see Siri and other voice services currently available on modern cellphones with language features. These functions would allow the driver to engage with the car in multiple languages and dialects, to improve user experience in the US, as well as to broaden appeal in other markets. Our study participants had some concerns about accents and intonations, which would be addressed if drivers could address the vehicle in their own language.

Mobile Gaming/Social Media Sphere

The internal space of the AV could be transformed into a mobile gaming and social media sphere, illustrated by Figure 5.4. The following are some suggested features that

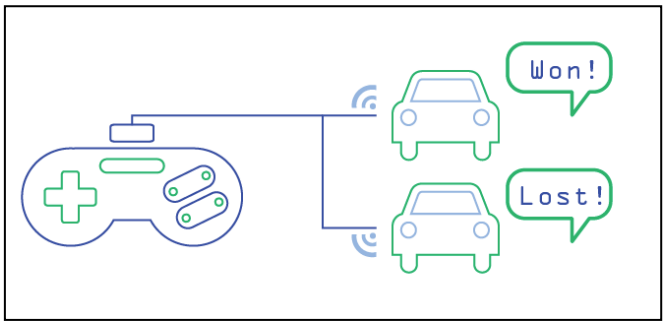


Figure 5.4. Social Gaming During Drives

would allow drivers to access this social/gaming sphere. A fully customizable experience could include projected screens displaying video games or mobile apps . A multiple controller set up could provide the driver with various consoles to interact with while driving. A social interaction could be integrated through those games with other drivers as well as friends, and those already within the driver's social sphere. This would be similar to the way that Candy Crush and other such games constantly issue invitations to play through social media sites (Facebook primarily).

Scanning the Driver

There is also the potential for active and passive scanners in the car to monitor the health and status of the driver, as shown in Figure 5.5. Such scanners would be customizable and removable, depending on the wishes of the driver. Loved ones could check in on the driver without interrupting the drive, if permissions were set up to give them access to the information. Much like GPS services where you can query someone's location if you both have the appropriate app, and be informed of where they are and where they are heading. The AV could transmit signals in the event of the driver being in distress to local emergency services. Ads and information tailored to the driver's likely hunger and fatigue based on length of drive (restaurants and hotels with deals) could be projected on a side display or screen. Suggested rest times could be displayed, possibly with exercises for the driver to engage in to avoid cramping, pain, or excessive fatigue on very long journeys. This would be similar to the way the Nintendo Wii interrupts every 30 minutes or so with a brief message proclaiming the benefits of rest and outdoor activities. If a driver became impaired, the vehicle could shut down, transport them to an emergency services facility or take them home.

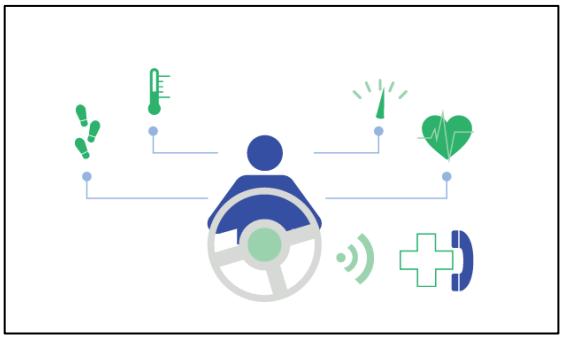


Figure 5.5. Passive Passenger Scanning

Streaming the Experience

AVs could also offer active streaming for car occupants wishing to communicate their drive experience with others, who could tune in or out as they wished. This would be similar to the way that video games, and cooking videos or home crafts shows are currently streamed.

6. Attending to Car Features and Objects in the Car

Molly Shade and Jung Kim

Research Findings

This chapter examines the ways in which drivers attend to car features and objects in the car. As demonstrated in the previous chapters, our study revealed that the car represents a complex web of social relations with those externally, internally, and virtually present. In other words, a vehicle is much more than mere transportation. The current chapter intends to build on this foundation by demonstrating that a car can be interpreted as an extension of its driver's body - a "prosthetic enhancement" that grants new properties to the individual (McCracken 2005:77). It is an intimate knowledge of a vehicle that makes driving successful. Using distributed cognition theory and the concept of mental mapping, we argue that understanding and manipulation of the physical environment of a vehicle are important aspects of the driving experience. These findings have direct design implications for the autonomous vehicle.

Distributed Cognition

Distributed cognition theory posits that technologies and environments store information to facilitate the actions of their users (Hollan et. al. 2000, Hutchins 1995). In so doing, they enable the users to accomplish tasks that they individually would not be able to do. Applied to vehicles, the infrastructure of the car does this, but more specifically, the particular calibrations set by each driver uniquely equip an individual to drive by decreasing the number of components they need to pay attention to. The car embodies elements of the driving endeavor by storing information. This can be observed in our participants' seat, mirror, and audio settings.

Driver's Seat

One clear example of embodied knowledge is the positioning of the driver's seat. If we conceptualize a car as an extension of its driver, the driver's seat is naturally a central component to a successful driving exploit. It is the primary vantage through which one experiences driving. Therefore how users interact with it is an important element in this study. When Mother Teresa, for example, turned on her engine, her seat automatically slid forward into a preset position. She noted that this added value in the form of comfort and ease to her driving experience. Dr. Pepper's car had the option of presetting four seat orientations for four separate drivers - her preferences were saved under button 'one' while her husband could press 'two' and have the seat arrange itself to his liking. This allowed for personalized place amidst several drivers. Interestingly, halfway through Burrito's interview, one of the researchers moved from the seat behind Burrito to the front passenger's seat wherein Burrito immediately moved his seat backwards. In this case, the driver had modified his chair preferences to be courteous to his guests, but quickly returned to his preferred position. All three of these cases illustrate how calibrating the driver's seat is a way for the car to store knowledge that directly facilitates the driving experience. Without this ability, the vehicle would be less capable of enabling successful driving.

Mirrors

Visual information was also stored in the anatomy of the car. Through interviews, it became apparent that drivers actively modified their car's visual settings in order to facilitate their experience. While Leonard was the only participant who explicitly said that he 'personalized' his mirrors, it was evident by the placement and frequent use of the side and rearview mirrors that they were arranged according to the stature and preferences of each driver. We found that drivers depended on this set-up particularly when backing up, turning, and merging lanes in traffic. Furthermore, Lucy had a second rear-facing mirror that was designed to see the inside of her car, specifically so she could keep track of her youngest son. In this way, our participants modified the arrangement of their car to improve their viewing capabilities. Again, interpreting the car as an extension of its user, the customization of mirrors increased the vision of the driver, therefore embodying to a degree the faculty of sight.

Preset Audio Controls

Participants in our study customized their radio controls to automatically generate a select few stations. This form of modification, we argue, is yet another example of embodied knowledge. Leonard, for instance, knew that NPR was his number one preset, and demonstrated the ease of this function to the researchers. Burrito, too, had individualized his radio, but he wasn't sure which number was assigned to which station, nor the exact stations he preferred. He often just scrolled through his preset list until he found something he liked to listen to. Nevertheless, he had narrowed his choices from the numerous radio frequencies available to his favorite six, which helped him to filter his options. Conversely, Sherlock explained that he hadn't programmed preset stations and that he had to manually twist the dial to change what he listens to, which bothered him (he had only owned the car for two weeks). While it could be argued that storing information about audio preferences doesn't directly influence the act of driving itself, music is a salient element in the driving experience overall, as explored in the next chapter. Therefore music memory should be interpreted as yet another way to enhance the driving experience through distributed cognition.

Mental Maps and Embodied Knowledge

The study findings also demonstrate that our participants could deftly navigate the features and objects that surrounded them, often without looking at them. They had internalized the spatial layout of their car. Mental mapping is a beneficial model to understand this. Mental mapping, in its most simplistic form, is an individualized, mental spatial representation of any given environment.

Applied to the driving experience, we argue that our participants used mental mapping to interact with their car. Furthermore, their knowledge of the car was not just in their heads – often it was in their hands. This was evidenced during instances where a driver successfully manipulated objects in the car without fully looking at what they were doing. In other words, the drivers had developed an embodied knowledge of their car that allowed them to multitask while maintaining their focus on driving.

"Blind" Controls

Adjusting volume and temperature controls is one of the most predominant examples of mental mapping. Sharknado, for example, regulated the temperature while singing, thumb tapping, and adjusting the volume to Haddaway's "What is Love?" while scarcely taking his eyes off the road. Similarly, Dr. Pepper frequently changed the temperature throughout her drive, sometimes in association with volume control, and rarely shifting her forward-facing gaze. Captain, too, modified the temperature during the drive with negligible eye movement - the entire endeavor lasting a mere two seconds. While driving, temperature and audio adjustments were often done with the right hand, relatively quickly, without verbal explanation, and depended largely on participant's embodied knowledge.

"Blind" Activities

Drivers in our study also multitasked frequently in other domains. Burrito retained focus on the road as he managed the audio and smoked a cigarette, glancing down only occasionally to orient his fingers. Further, he relied solely on his mental map to replace his beverage in its holder after each sip. At one point in Lucy's interview, she began to rustle through various compartments in her car to try to find a charger for her son's game. She briefly lowered her gaze amid rummaging and explained that she rarely looks down for long periods of time and uses touch instead. Similarly in another interview, Sherlock looked down to the center console, used his right hand to open and find a pair of sunglasses, confirmed the right pair with another glance down, and then closed the console and put on the sunglasses without taking his eyes off the road again. All of these examples indicate that our participants relied on their embodied knowledge of their car, direct touch, and minimal vision to interact with features and objects in their cars.

"Blind" Driving

The use of embodied knowledge may even extend to the operation of the car itself. At one point during his drive on the interstate, Buddy removed both hands from the steering wheel to reach for, unscrew, and drink from a nearby water bottle (this was also done repetitively by Sharknado). In reviewing this clip, Buddy explained that he felt comfortable doing so, even at 70 miles per hour, because he understands his car. He further explained that this particular car pulls towards the left and he often uses his knee to counteract that motion. This degree of familiarity with the car's setup and performance suggests that our participants have developed a deep knowledge of their vehicle which affords them the ability to expertly navigate other tasks simultaneously.

Adding to the Mental Map

Our findings revealed that participants often added devices to the car to facilitate their driving experience. These objects were placed in conspicuous, accessible areas that were easily incorporated into their larger vehicle mental maps. Leonard, for instance, preferred using his phone to traditional GPS systems and would place it on the center of his dashboard so he wouldn't get distracted looking toward the center console, his lap, or his hand. Conversely, during the drive we observed, Burrito originally set his phone in the cup holder but migrated it to his lap for the majority of the ride to facilitate its use. Because his phone played a large part in his driving experience, being able to know where it was without looking was a key component for him. Sharknado, too, interacted with his mp3 player frequently and would keep in it his hand or his lap for quick reference and manipulation. These are all examples of how participants *added* to their vehicle's mental map. By integrating outside devices in an accessible manner, they effectively expanded the features of their car and, simultaneously, their mental maps.

Implications

Based on the findings from this research project, we have developed the following design implications for autonomous vehicles.

Maximize Customization

In our discussion of distributed cognition, we demonstrated that our participants experience driving through an intimate understanding of their car. Notably, we showed that customization of their vehicles (i.e. seat positioning, mirror set-up, and preset audio preferences) augmented their ability to interact with the car and therefore the task of driving. We advocate, therefore, for the maximization of modification possibilities (physical, visual, auditory).

Furthermore, we suggest that enabling cars to 'save' these preferences would improve the overall experience of the driver. Having each individual car feature perfectly calibrate itself to the current user at the push of a button or sensing of a key fob would enhance the driving experience. As seen in Figure 6.1, a key fob has saved the temperature settings, seat positioning, mirror set-up, preferred radio stations, and even entering/exiting theme music. These preferences can be adjusted either en route or with a wireless device or computer.

Extending these preferences to vehicles other than those that an individual owns would have even broader effects. Borrowing a friend's car and knowing the physical, visual, and auditory make-up would instantly align with your driving style may improve the driving experience outside of the ownership model.

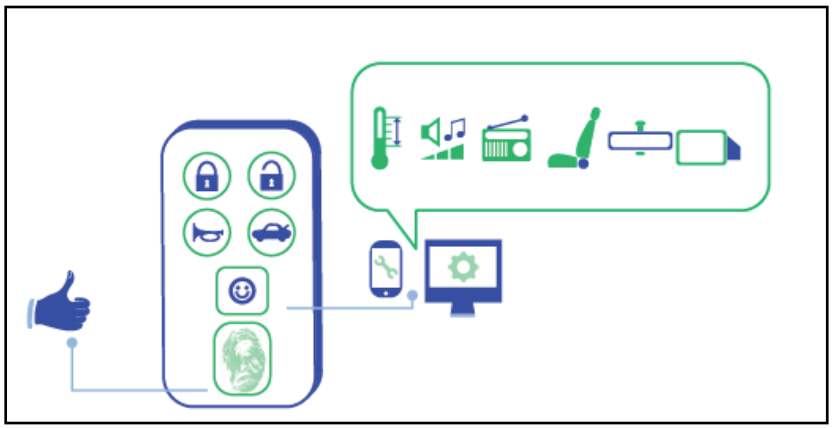


Figure 6.1. Vehicle Customizations Saved on Key Fob

Non-Visual Feedback

Because so many of our participants relied on mental maps that require touch but not eyesight to navigate the exterior and interior aspects of their car, we suggest developing non-visual feedback, as illustrated in Figure 6.2. Drivers in our sample often multitasked in managing controls, devices, and social spaces. Therefore enabling engagement with these activities through haptic, audio, or displaced visual feedback may be a beneficial addition to future AV models. Further, as alternative methods of interacting with cars become more possible, features such as hand and face recognition systems or voice control may be promising additions.

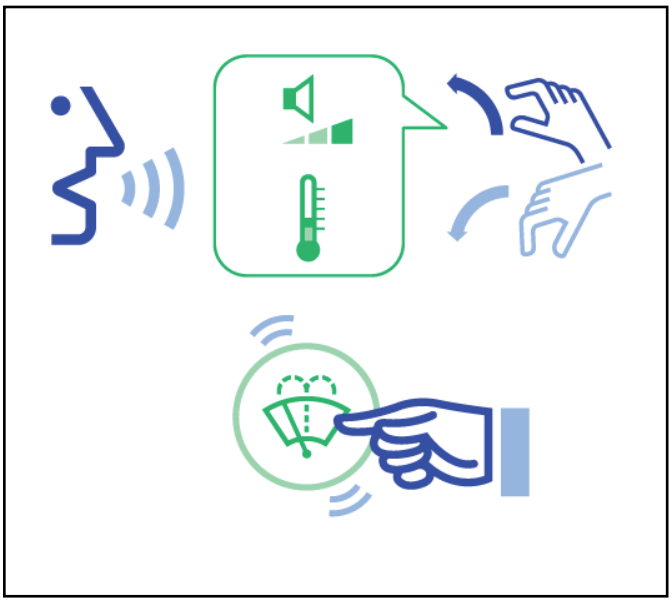


Figure 6.2. Non-Visual Feedback

A second-tier implication here is that touch screens as they exist today may not be the optimal interface for vehicles. Interacting with a touch-screen GPS, for example, often requires significant eye engagement and some physical behaviors. Buddy explained this phenomenon as it applies to cell phones, "Touch screens are making texting and driving more dangerous because you have to look at your phone. Whereas when I had a keyboard phone, I could look at the road and type without having to look at my phone."

Therefore we propose that it may be beneficial to include vibrations, increase reliance on voice, or move the visual feedback into the driver's forward-oriented vision.

As vehicles become more automated, though, orienting one's attention towards the road may become less important. If this is true, non-visual feedback may be less pertinent. However, during the transition period to fully autonomous vehicles, understanding that visual feedback is possibly a weaker form of HCI may play an important role.

Interactive Tutorials

If we understand cognition in terms of its social, physical, and historical contexts, adapting car tutorials to this model may be advantageous. When people buy a car, they are often presented with a brief overview of all of its functions, offered a test drive, and handed a printed manual. If, however, a car were supplied with an interactive learning tutorial, drivers would be able to learn about their new vehicle through interaction with the physical features and add to their understanding of the car.

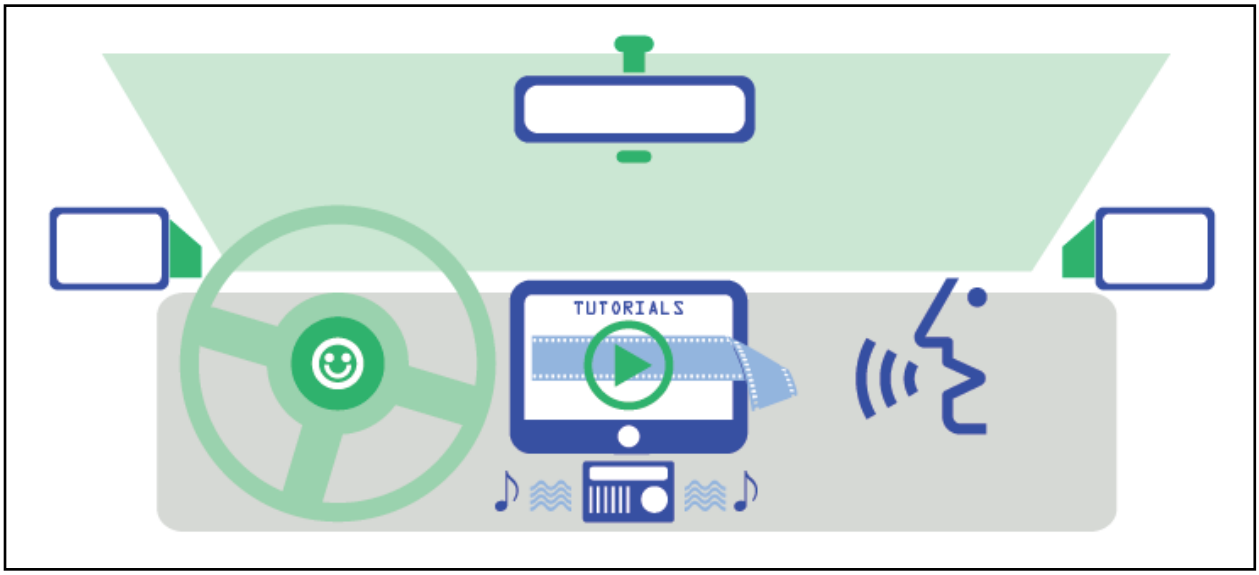


Figure 6.3. Interactive Tutorial

7. Other Activities

Hira Hasan and Jung Kim

Research Findings

This chapter examines all driving activities not described in previous chapters. It discusses activities that the participants either indulged in during the drive or said they would like to do if they were not driving. The most common activities turned out to be listening to music/radio, followed by singing along with music alone or with others, and drinking/eating. Activities are described below in their order of frequency, starting with the most common. These activities are likely to increase in AVs as people are freed from the need to focus on the road.

Listening to Music

Listening to music/radio was a pattern that was common to all nine of the participants. Burrito kept changing the radio stations during the ride. Mother Teresa said that sometimes she listened to music while driving. Buddy was a big fan of Christmas music and said that he listened to it throughout the fall and winter. He mentioned that music was the best part of the drive. Sharknado wasn't just listening to loud music but constantly kept changing songs on his iPod every few minutes. Leonard mentioned a couple of times during the ride that music was essential while driving and usb ports for that purpose were very important to him. Captain also adjusted music on the way back of her ride more frequently as she was not on the highway and more relaxed. Lucy said that radio was mostly played in the vehicle but her daughters used to get annoyed by actual changing of the radio stations and thus prefer listening to music on their portable devices. Sherlock said that he mostly played the radio while driving but was too conscious to do so on that particular ride as he was being recorded. The importance of music/radio during the driving experience was shown as participants either mentioned their need for music while driving in their conversation or physically interacted with the radio or audio device during our driving observations.

Drinking and Eating

Drinking/eating while driving was also a prevalent theme. While there weren't any observations of anyone eating, Lucy mentioned that her children ask for food and drinks while riding the car but she tries to enforce a no eating/drinking in the car rule. Buddy took sips from his water bottle about three to four times while driving during a forty five minutes ride. In one instance he removed both his hands from the steering wheel for a few seconds to take a sip. Sharknado very frequently sipped water from his water bottle as he enjoyed his morning drive. He sipped water almost as frequently as he changed songs on his iPod. Burrito accompanied his cigarette with a Red Bull drink and kept taking sips from the can as he drove and smoked. Dr. Pepper mentioned that she loved to have some drink (water/coffee) while driving and during the driving interview she cautiously had ice-cream at traffic signals.

Singing

Singing along to music was a popular activity as well. Buddy mentioned that he liked singing while driving. Sharknado demonstrated active singing with the music throughout the ride, accompanying songs with his high and low notes. Burrito also lip synced to a song for a bit when he got comfortable with the researchers in the car. Captain revealed that at the traffic signal she liked singing along with the music. Leonard also mentioned that he and his wife would sing along to music and make each other laugh in the

car. Mother Teresa believed that she was too old for loud music but she did sing along while driving. Dr. Pepper revealed that she enjoyed singing either alone or with friends in the car.

Sleeping

Buddy stated a couple of times that he liked sleeping in the car and whenever he was not driving on road trips, he slept. He also said this was the case with his friends, they either slept or talked if they weren't driving. Mother Teresa loved to sleep if she didn't drive, but felt obligated to the driver to stay awake. Captain was thrilled at the idea of a self-driven car so she could sleep during road-trips. Dr. Pepper said that she would sleep in a self-driving car but on second thoughts, she would rather stay awake to monitor the vehicle and for the same reason, Burrito was also apprehensive about sleeping in a self-driving car as well.

Dancing and Drumming

Music was also accompanied by physical movements by a few. Sharknado danced on the driving seat and drummed the steering wheel as much as the space allowed, as he drove. He seemed to be full of energy and enthusiasm. Dr. Pepper also mentioned that she enjoyed singing and dancing with her friends in the car. Leonard drummed the steering wheel a few times during the ride but that was more out of frustration of the traffic rather than enjoyment.

Playing Games

Lucy's kids were the only example of people playing games in the car; they were the only children in our research. However, Dr. Pepper also mentioned that she would like to play video games in a self-driving car.

Alone Time

Buddy viewed driving as his time alone. He stated that he enjoyed himself while driving alone since he is an introvert. Dr. Pepper also said that she enjoyed in her car with friends as well as when she was alone.

Watching TV and Videos

Burrito said that he would like to watch music videos while driving, while Dr. Pepper said that she would like to watch TV along with other activities in an automated vehicle.

Activities Mentioned by a Single Study Participant

There were some activities that were brought up by participants individually. Mother Teresa was the only one who mentioned that she liked listening to audio books while driving. Later she also revealed that she liked reading on long trips if she wasn't driving. Burrito smoked throughout the drive and seemed pretty comfortable with it. Every now and then he had to ash the cigarettes which he managed pretty well along with handling the steering wheel. Burrito was also the only example of grooming in the car while driving but it could be a significant activity in an automated vehicle. He fixed his hair looking in the mirror at a traffic signal.

Implications

This part of the chapter presents some ideas as to how the activities described above can be facilitated in an automated vehicle, as illustrated by Figure 7.1. To start with, being able to talk to the car would be comforting for the passengers. People could give a name to their car, communicate with it, and the car could help them in performing these activities. Perhaps they could ask for assistance with all the desired

activities. Figure 7.2, at the end of the chapter, shows a possible inside view of an automated vehicle and how the discussed activities can be facilitated.

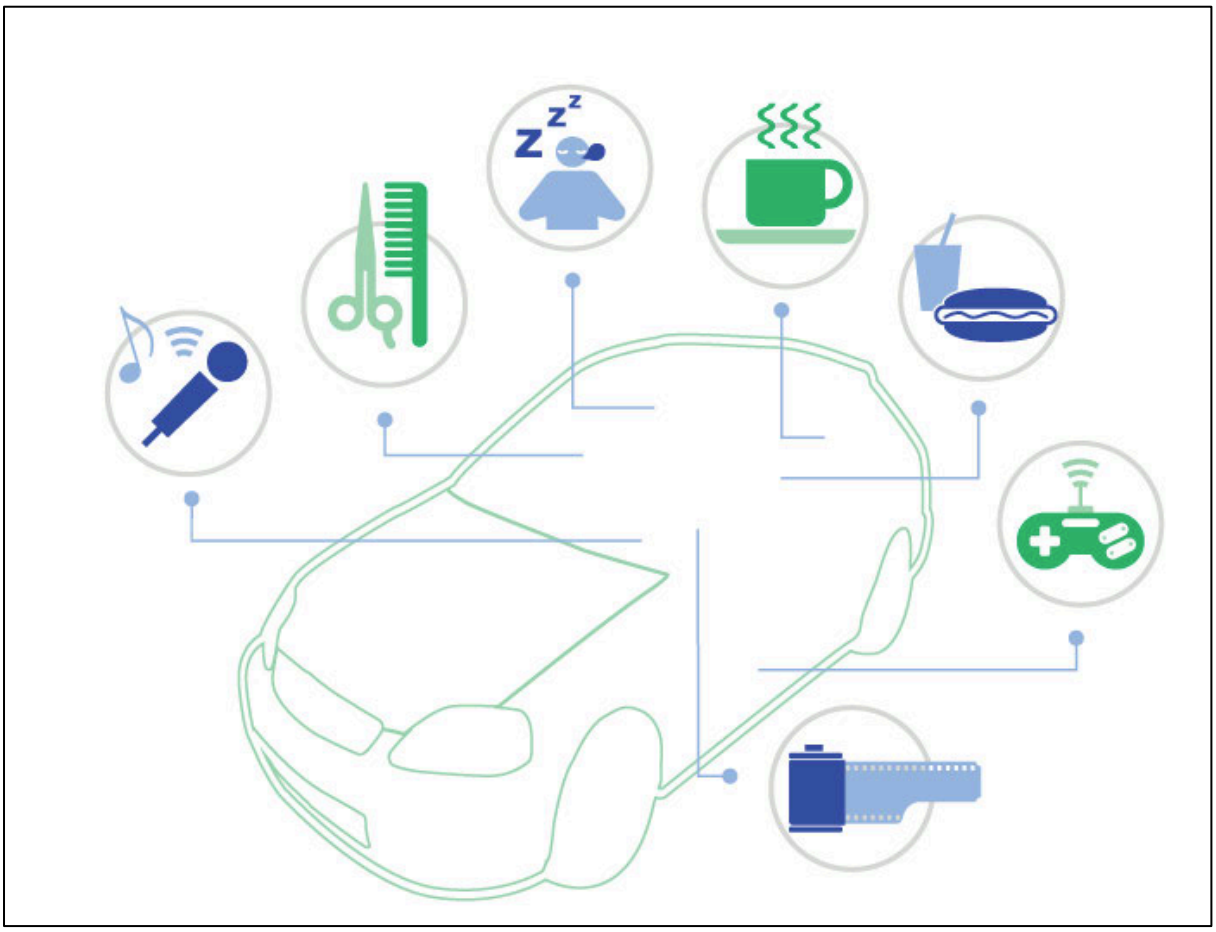


Figure 7.1. Autonomous Vehicles Could Support a Variety of Activities

Multimedia System

A multimedia system could provide the entertainment requirements for listening to music/radio, singing along, watching TV/ videos, and playing video games. The multimedia could include radio, hookups to devices to play music, and a CD player, for music. Although some participants enjoyed the radio, others were more specific in their audio needs. A user-friendly, multimedia music system would allow choices for commuting drivers depending on their needs. Buddy liked to listen to his Christmas music all year, so a CD player or hook-up for devices is necessary. Mother Teresa listened to her books on tape, so device use depends on the format of her audiobooks. Captain simply hated the radio and preferred listening to her own music while commuting. The inclusion of a large, digital screen would allow drivers to watch music videos or have a visual to accompany their music if that feature was desired, as mentioned by Burrito and Dr. Pepper. Participants like Sharknado danced to much of his music and might appreciate the addition of visuals to enhance the audio. Ensuring constant audio access in a variety of forms would greatly increase the enjoyment of the commuting experience for many users. As seven out of the nine research participants were into singing while in the car, karaoke integrated within the multimedia system would make the sing-along experience more pleasant, especially if accompanied with improved acoustics for the car.

Food and Drink Preparation and Storage

Eating and drinking were popular activities in the car, so a microwave and a fridge would be useful. Cup holders that could keep the drink warm/cold and small platforms that could keep the food warm would also support these activities.

Cleaning

Most of the women in our study were very particular about the cleanliness of the car. Dr. Pepper and Captain mentioned that what went in the car had to come out with them. Lucy said she was not concerned about the aesthetics of the car but was very particular about the cleanliness. Cars could include a garbage disposal system to help manage food waste, the kind which is integrated in the kitchen sink. To maintain the car's interior, there could be a rubber coating so that it can easily be cleaned, or automatic brushes, like windshield wipers, to clean the seats. Since smoking is one of the activities that creates a mess and a bad odor, a better exhaust system would be beneficial, maybe a small exhaust fan at the side of the rear windshield.

Bed

Sleeping was a frequently brought up topic, however participants were a bit skeptical about sleeping in an automated vehicle. Nonetheless, if passengers are totally comfortable, sofa-cum-bed kind of seats would be beneficial and relaxing.

Supporting the Movement of People in Moving Cars

A slightly higher ceiling of the automated vehicle will facilitate these activities and the passengers' ability to move around. However, motion sickness and the safety of passengers (at jerks or when the car turns) would be significant constraints for all such activities, and require further thinking these processes through.

Storage Needs

Many of these activities require storage space for objects like toys, books, board games, CDs, a grooming kit, microwave, or fridge. Storage issues will be explored in the following chapter.

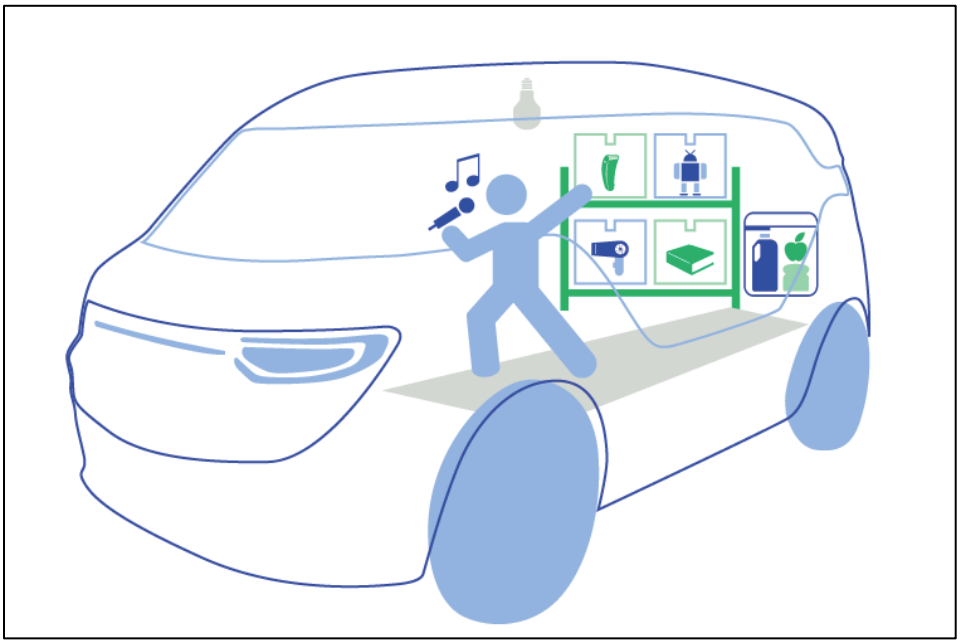


Figure 7.2. A Possible Inside View of an Automated Vehicle

The Role of the Car in People's Lives

8. The Car as a Mobile Locker

Alexandra Hickling and Austin Hartt

Research Findings

While participants expressed some preferences for storing items within their vehicles, the field video documenting tours of their cars and the driving experiences yielded the most insights on this topic. By conducting an inventory of each participant's vehicle with focus on the placement of objects, patterns among participants' values and their perceptions concerning the utility of the car were revealed. The full inventory is presented at the end of the chapter. Themes of security and accessibility complemented participants' conceptions of vehicle function. The way participants interacted with the various compartments inside their cars and what they chose to bring into, leave in, and take out of their vehicles all indicated how safe they felt storing valuables in the car, as well as the accessibility, frequency and prioritization of item usage.

From Space to Place

Our team used conceptions of space and place to better conceptualize how participants occupied space themselves and made place out of their space through personalization—bringing items into the car, organizing them, interacting with them, and selecting what stayed and what went upon reaching destinations. *Spaces*, as reasoned by various scholars (Harvey 1996; Tuan 1977), are unscripted geographical locations. *Places* are spaces given symbolic meaning through patterns of use and the assignment of a particular significance. In the case of our participants, their cars are spaces turned into meaningful places through the occupants' activities and personalization.

Our study participants were not always articulate about how they used their own space. Often, they would just point out items within different compartments of the car, listing them in the order in which they first saw them rather than the order of usage prioritization. While many of our participants expressed item placement in terms of need and degree of accessibility, few articulated their modes of organization until prompted. This reveals how the car itself has become a place of second nature, an area where the occupants acquire specific expectations upon entering the car, meaning everything should be in its place.

Often, it was easier for participants to articulate why they placed items in specific spots when talking about how they felt after someone else drove their car or how they set their seat and music volume. Objects and settings seemed out of place or different from their original setup. Mother Teresa described this kind of taken-for-granted knowledge, "You get used to how yours goes and where everything is." One participant, Sharknado, was able to articulate the usage of his car space by relating it to other places he stores items in his life. Sharknado described the various spaces in his car, especially the trunk and back seat, as "the treasure chest" of his life, "a mini representation" of his home, "a transportable locker," "maybe not a house, but a room," "a backpack or purse," and "a closet." These concepts of the car as a place provide a lens into how drivers utilize their car and express their vehicle's general everyday function. Sharknado was most likely able to articulate the use of his car so descriptively, because of the many functions it provided him. As a college student commuting over an hour to university, his car became a place of convenience and necessity. For him this meant a place for all the "stuff" he needed to

have available when necessary, even if it was something he would not use on a daily or even weekly basis.
While Sharknado expressed the need for his car to be something more than a tool to get from location to location, a majority of participants claimed to simply use their car for transportation (to get to work, to get from point A to point B). However, the items they stored in their car told a more complex story about the utility of their vehicle. While all participants' cars might not be considered "a treasure chest" of their lives, many could certainly be defined as a mobile locker, where occupants temporarily stored, organized, and selected what went in and out on each driving venture.

Assigning Objects to Particular Spaces and Prioritizing Their Accessibility

In our study we found that particular areas within the vehicles were personalized based on the way in which the "stuff" people brought into their cars was organized. The spaces within the car were given symbolic meaning, defining the place the car became for its occupants. Our findings revealed patterns in how study participants used the interior of the car as storage, from the trunk to the front end.

We found that the frontal areas of the car tended to be highly organized, especially the area around the driver seat and glove compartment. These spaces were typically organized around the driver's priorities in terms of what items they wanted to access most easily when driving. Items of importance in terms of placement in these frontal areas included: mobile phones, electronic audio media player devices, sunglasses, and coin storage. Figure 8.1 and 8.2 illustrate Sharknado drinking and changing a song on his iPod. These images show how he prioritized his space based on immediate need for items during his hour-long commute.

Figure 8.1. Sharknado Drinking and Driving

Figure 8.2. Sharknado Song Selection

Back areas of the cars typically held an array of various different items that did not need to be accessed so easily, especially in areas like the trunk or backseat floorboards. Objects being stored in the back were typically emergency kits, specifically jumper cables, work or hobby-related items, and "just in case" items.

"Just in case" items varied by participant. While participants like Sharknado kept what he would call his "life" in the trunk of his car, including spare clothes and books, participants like Captain kept the bare essentials, or maintenance items like tools and a spare tire. Frequency of use and a person's desire to engage with an item during driving affected item placement. For example, phones and sunglasses were high priority items, given designated spaces in the front of the car and in close proximity to the driver. Jumper cables and first aid kits, while defined as essential to have available within the vehicle, were not used frequently or while driving. Dr. Pepper claimed the placement of her first aid kit located in her trunk to be a good place, because she expressed that she would need to stop and park the car before attending to

any issue of that nature. It was also out of the way from the items she wanted immediate access to. While designers create spaces for car occupants to store items with particular uses in mind, often spaces in cars are used not only for their intended purpose but are also adapted by participants to customize their mobile locker space.

Nine out of nine participants used their cup holders for something other than their intended purpose. A majority of participants had put their phones in the cup holders while some had loose change or an iPod that sat within. Mobile phone usage during driving experiences was rated high among our participants. All participants had some sort of center console, but seemed not to use it for items they needed to have immediate access to. Burrito expressed that he did not keep much in his center console because it was not easily accessible while driving. He typically used the compartments conveniently located on the dash—one over the radio and one under the air-conditioning unit. These areas created less physical strain on the driver's body, minimal effort, and less focus taken away from the road. More than anything, center consoles were used as an arm rest. Direct access to phones, purses, and music devices was typically ensured by locating them in cup holders or on the passenger seat.

Safe Keeping Practices

Research findings showed varying degrees of security and notions of safe keeping across participants. Out of the nine participants, Sharknado carried the most items in his car. Having space to store "just in case" items like extra clothes and books was significant and being able to have a place he could name "treasure chest" to keep all the things that make his life convenient impacted his conceptions of storage. Therefore his comfort level for keeping and leaving items in his car needed to be high. Burrito kept his wallet, inhaler and passport in his car. He felt his vehicle was a safe place to store those items. On the other hand, Dr. Pepper, because of a previous experience where objects were stolen from her car, felt like she could not leave valuables inside and chose to take out whatever she put in the car, unless it was easily replaceable, like cleaning supplies that she kept in the trunk. She kept everything securely inside compartments which made her car look clean, but also rather barren. For items in her trunk that did not have compartments, she bought an organizer to place them in and had a cover that slid over the items and covered everything stored in the trunk. Figure 8.3 illustrates this cover and organization. If anyone were to look in, the items would be hidden from view. When Dr. Pepper looked into purchasing a car, features and compartments that prevent theft and hide away items was an important selling point.

Figure 8.3. Dr. Pepper's Notions of Security

Most participant vehicles had compartments that closed. This left little to be seen if the occupants decided to shut them. Dr. Pepper had many such compartments in her car, but seldom used most of them or only temporarily stored items in them. Leonard was very minimalistic and kept only items that he needed for work in addition to emergency items like jumper cables in his car. Sharknado left much of what he

brought into his car. Participant responses provided evidence supporting how important having spaces secure from break-ins is to future design implications.

Implications

In terms of storage, the notions of space and place are important considerations that (1) reveal meanings behind human behaviors within the interior of the car and (2) suggest implications about how future car designs could better respond to consumers' needs and wants.

Most participants kept their most immediately needed items, a phone for instance, up front in a cup holder, passenger seat, or center console. Most participants used the trunk to store items that would habitually stay in the car. The backseat was the most varied. Some left items in the backseat that they would need upon arrival to their destination, like a backpack or briefcase, while others either stored nothing back there, had items for entertainment, or even just trash they had yet to throw away. These findings revealed a concern with accessibility as well as safe keeping. The implications concern the allocation of space, the ability to make a space a place, and the secure organization of items.

As autonomous vehicles approach Level 4, the behaviors of car occupants are likely to evolve in various ways, including how they engage with the car itself and its respective spaces. Drivers or car occupants will continue to create their own personalized place out of the space the car provides, producing a symbolically meaningful setting to express ownership. While the shape and amount of space available in the vehicle might change, occupant desire for both secure and accessible compartments will still remain. Designers will need to continue thinking of new ways to hide items occupants do not want seen and create accessible and easy to use spaces.

Customizable compartments that can be moved around the space rather than stationary fixtures may be an avenue to explore. By giving occupants the ability to move storage units or compartments around, customization and creation of place can be facilitated. Modular storage units would allow occupants to exercise creative will and define their own conceptions of convenience and security. In addition, unconventional storage spaces, perhaps in the floorboards or walls, could not only provide occupants with more space, but also incorporate more secure spots for items brought into, stored, or left in the vehicle.

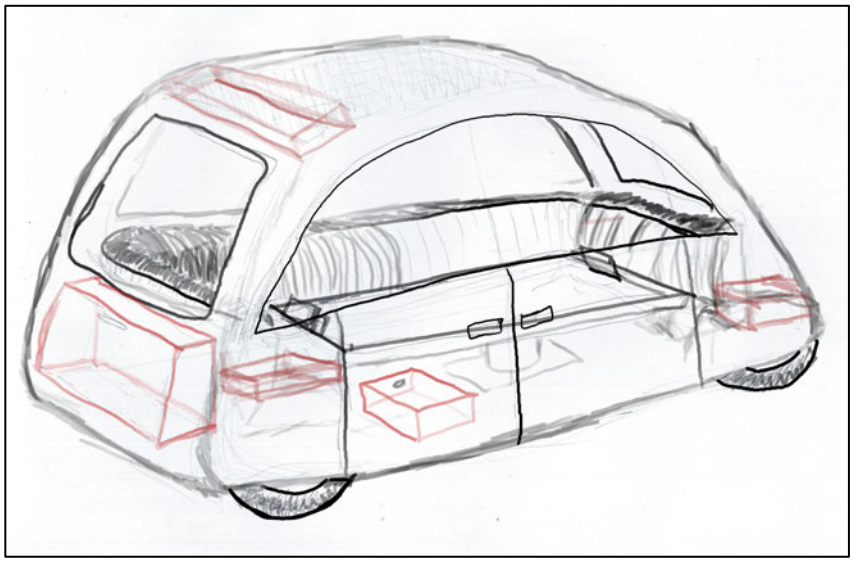


Figure 8.4. Storage Space in Pod-Like Model

Replacing bulky center consoles that beg "open me" with more subtly integrated storage spaces might be something to consider. Figure 8.4 illustrates some of these points through a pod-like model with storage space ideas highlighted in red. Figure 8.5 shows storage behind and under seating, where the occupant would access the storage points by either flipping up the seat or removing a front panel.

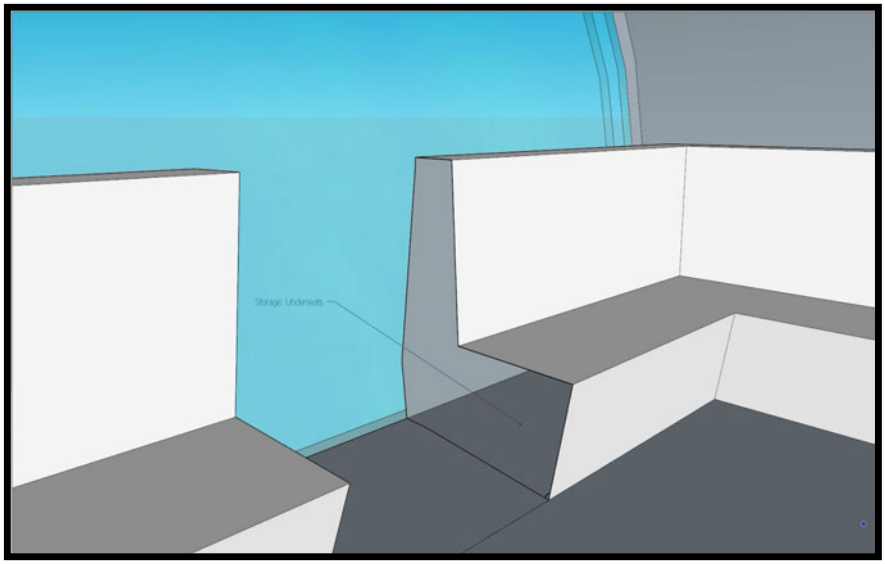


Figure 8.5. Storage Space under Seats in Pod-Like Model

Finally, items included in the inventory of participant cars provided examples of what people typically bring into and leave in their cars. Figure 8.6 on the next page includes the full list of items seen in all nine cars. This list can offer size and shape ideas for future compartments. Storage spaces for both work and entertainment should be considered. As AVs become increasingly more like a mobile extension of one's house, it seems likely that the car will increasingly become a place for both work activities formerly conducted in the office, and leisure behaviors associated with the home.

Who	Front	Back	Trunk
Buddy	**Center Console**: Check receipts **Cup Holders**: Vitamin water **Compartment in Front of Gear Shift**: Not used (covered by drink if cup holders in use) **Doors**: Miscellaneous papers, napkins **Dash**: Used for job—delivery tags	**Seats**: School supplies, sunglasses, work hat, shoes, frisbees	Frisbees, jumper cables, tire air inflator, towels, mesh bag, cardboard box
Burrito	**Glove Compartment**: Coin cylinder, car manual, miscellaneous papers **Cup Holders**: Ash tray, inhaler, change **Console under Radio**: Wallet, papers, pen, passport, calculator **Console (Top near Dash)**: CDs, charger, medicine, inhaler **Small Overhead Console**: Sunglasses	**Dash**: Miscellaneous papers	Soccer shoes, soccer ball, car seat, jacket, book
Captain	**Passenger Seat**: Jacket **Cup Holders**: I-Pod, GPS	N/A	Jumper cables, spare tire, extra air fresheners, extra pair of sunglasses
Dr. Pepper	**Cup Holders**: Drink, mobile phone **Center Console**: Baby wipes, change, garage door opener **Glove Compartment**: Reusable grocery bag, tire gauge, car manual, flash light, key chain, insurance cards, CD **Driver-Side Door**: Hand sanitizer, napkins, umbrella	**Seat**: Jacket	**Car Organizer**: paper towels, Windex, leather cleaner, rag, beach towel, magazines, trash bags, IKEA reusable bag, steering wheel cover **Side Panel**: first aid kit
Leonard	**Cup Holders**: Drink **Passenger Floor**: Trash bag, umbrella	N/A	Car maintenance and emergency items
Lucy	**Driver-Side Door**: Magazines **Center Console**: Chargers, miscellaneous items	Kids' and various electronic devices (phones, game devices) **Door Panel**: Colored pencils and markers, sharpies	Basket, booster seat
Mother Theresa	**Doors**: CDs/audio books **Cup Holder**: Mobile phone	N/A	N/A
Sharknado	**Passenger Seat**: Water bottle **Central Cup Holder**: Mobile phone, iPod, sunglasses **Plugged In**: Phone charger, MP3 connector/adapter **Rearview Mirror**: Rosary **Dash**: Beanie baby animal **Center Console**: Change, gift cards **Driver-Side Door**: Duct tape	**Seat**: Jacket, more clothes **Backseat Pockets**: Maps, miscellaneous papers	Small suitcase with clothes—"go-bag", books, board games, gym bag emergency equipment—(jumper cables, tools), backpack, shoes
Sherlock	**Center Console**: sunglasses	**Floor**: hat	Reconstruction gear for job

Figure 8.6. Study Participant Car Inventory

9. The Car as a Means to Accomplish Work

Heather S. Roth and Austin Hartt

Research Findings

Introduction

The car as a means to accomplish work was manifested through commuting and commuting behaviors. Rather than using the car to perform work, study participants contemplated their commute as the primary function of the vehicle. This chapter aims to demonstrate the way work within the car was envisioned by participants and the ubiquity of commuting that permeated the driving experience. Implications will focus on ways to incorporate work-related tasks in Level 4 autonomous vehicles and how the commute can be enhanced for the benefit of drivers.

Factors that Inhibit the Ability to Work in the Car

Although the car was used for transporting oneself from home, to work, and back, it was seldom used for work-related activities. During the driving observation, no study participants were observed conducting work in their cars although the presence of the researchers may have discouraged the completion of work-related tasks. When used here, the term "work" refers to activities related to an occupation, or schoolwork, such as checking emails, making phone calls for a job, or completing paperwork. Captain, a student and a worker, spoke of the desire to work in her car during the post-driving interview phase. Sherlock, a retired cop who now works on crash reconstruction, explained how he took work phone calls in the car while driving in a convertible. The other seven participants did not mention doing work activities in the car at any time during the interviews.

In interviews, study participants did talk about the possibility of working inside a self-driving car. Most participants were enthusiastic about using driving time for other meaningful activities. However the activities described were mostly for entertainment, and only one participant mentioned her desire to use that time for catching up on work tasks. When asked about the opportunity to travel in a self-driving car, Captain said she would use that time to "study for a test, check emails, text" or watch an episode of a show for entertainment.

Varying factors played a role as to why, or why not, drivers completed work in the car. For example, during the driving interview Captain stated that she couldn't do work in the car because her phone lacked internet capability. The internet would have allowed her to check work emails or complete school tasks. Many participants did not conduct work-related activities in the car because they had a specific code of conduct regarding electronic devices while driving for safety reasons. These codes may facilitate or inhibit work activities in the car and varied according to each participant.

Another barrier to working in the car was specifically related to the parameters of time surrounding the commute. Some participants had short commutes and therefore did not have much time for work (or other activities). Other participants had longer commutes but primarily drove on smaller roads that required

most of their attention. On freeways, participants seemed to experience the most freedom to talk, look around, and interact with objects in their cars.

A brief profile will be provided to demonstrate the varying lengths of time participants spent in their cars while commuting. A "commute" is defined as the travel in one's car to reach school or work. Only five of the nine participants are accounted for in this section. Lucy is not counted because she was a stay-at-home mother without a regular, daily commute. She used her car for taking the children to and from activities and completing housework tasks. Sherlock is not included here because he drove to constantly changing work sites. Dr. Pepper is not included because she worked from home and only drove for meetings with her boss on occasion. Finally, Buddy is excluded from this section because, as a pizza delivery driver, he used his car to accomplish the work task. The remaining five participants and their commutes are described below:

- **Leonard**: commuted about 30 minutes on the way to work and about 45 minutes on the way back.
- **Mother Teresa**: commuted about 30 minutes each way to work.
- **Sharknado**: commuted about 1 hour to school and often stayed with a friend near school to avoid constant commuting.
- **Captain**: lived in between work and school, thus commuting equally to both (about 35 minutes) so that her commute wasn't as long one way.
- **Burrito**: lived close to school (within 15 minutes) but still commuted there many times a week.

Commuting: a Liminal Phase between Home and Work

Commuting is a liminal-like period that serves as a bridge between the home life and the work life. Liminality is an anthropological concept that refers to the phase of disorientation that can occur when one is transitioning between two places (Turner 1967). Participants often spoke of their regular commutes to work or school since that time constituted a significant portion of their day.

Understanding how the commute is a period of fluctuation may address why participants engaged in the activities that they did while driving. First, commuters bring work and personal items into their cars. One example was how Sharknado put his backpack in the car before setting off on his long drive to school and situated a water bottle near the driver's seat. No participants were observed putting work equipment in their car, but we can infer that most individuals normally bring work and personal items into the vehicle prior to commuting. Similarly, some or all of these items are taken out once they arrive at work, and the process is repeated on the way home. These short transitions into, and out of, the commuting experience are crucial to understanding why the commute is so transitional. The coming and going of personal and work belongings influences what the driver interacts with during the commute.

Even so, bringing personal items into the car does not alleviate negative emotions towards commuting. Five out of the nine participants expressed an annoyance or hatred of their commute because it was negatively affected by internal and external factors. Below are a few examples of participants describing their commute:

- **Leonard**: "In a quarter mile stretch I have to pass over the same train tracks three times."
- **Mother Teresa**: "I try to be engaged and focused and paying attention while driving...it just kind of depends on what the traffic is or whatever, it can be kind of exhausting." On her way home from work Mother Teresa says, "I get so sleepy."
- **Sharknado**: He describes being in traffic during his daily commute to school. "This is like, my morning, every time I drive to [town name], it's this part that really annoys me."

- **Captain**: She says, "I hate driving" because it is just something she has to do, not necessarily what she wants to do.
- **Dr. Pepper**: "It's still annoying, the having to be stuck in traffic, and I need to waste my time."

Optimizing the Commuting Experience: Internal and External Factors

Study participants regularly attempted to optimize their commuting experiences by adapting to or managing internal and external factors. Internal factors are elements that participants have the ability to manipulate inside of their own car. Music, AC/heat, and use of devices are examples of internal factors. External factors are elements that participants experience on the outside of their car and that are beyond their direct control. Traffic, weather and road conditions, and school zones are examples of external factors.

The most commonly controlled internal factor was an assortment of audio functions. Participants often played music and spoke about how important music is to them while commuting. Although Chapter 7 describes this phenomenon in more detail, it should be noted that controlling audio was observed as the most salient internal factor controlled by study participants. Electronic devices were similarly employed during the commute in personal and social ways. Chapter 5 illustrates the connection between virtual activities conducted through such devices and how that provided a connection between the driver and others outside of the car. In addition, devices generated the freedom to entertain oneself through a variety of mediums such as social media, news outlets, and videos. Other internal factors such as temperature and the consumption of beverages were commonly observed among study participants as a means to enhance the commuting experience.

External factors are much more dynamic because they are often beyond the control of the driver. The most commonly cited external factor by participants was traffic. Participants employed creative strategies for avoiding congested traffic conditions during their daily commute. Sharknado, for example, would leave extra early to avoid school zones near his home and heavy traffic on the highway. Buddy took roads that were quick and easy because he disliked merging onto the highway into traffic. Sherlock, when driving from worksite to worksite, would avoid small roads and stick with major highways to avoid local traffic. Traffic often blended with road conditions and the behavior of other drivers. All three elements contributed to commuter routes and how a driver might change their habits. Other examples of external factors that were usually avoided, per the participants, are railroad tracks and construction zones.

In contrast, scenery was often chosen by the driver to enhance enjoyment of a commute. Preferences varied among participants, but many agreed that the world around them played a pivotal role in their enjoyment of a commute. Captain chose to drive home a different way than when she went to work so that she could enjoy trees and flowers while commuting home. Her commute to work ignored aesthetic elements and mainly focused on avoiding heavy traffic. Mother Teresa followed the same pattern of thinking. On her way to work she took the freeway and on the way home she avoided the highway, enjoying a slightly longer route with a pleasant landscape. Sharknado attempted to control external surroundings through precise timing, setting out on the highway at just the right moment to avoid traffic and enjoy the sun rising on beautiful scenery. Participants like Buddy were not able to regulate so many factors of the driving experience while working because the job dictated where he drove.

The Car Accomplishes the Work: A Case Study of a Pizza Deliveryman

Commuting is a common activity between home and work, but there are cases where individuals may have to drive in order to accomplish a particular work task. Buddy exemplifies this type of driving through his job as a pizza delivery driver for Domino's. Although Buddy commuted to school on a regular basis, he also worked Friday and Saturday nights delivering pizzas within a specified zone. In this

way, the liminal phase of the commute was drastically affected. Commuting was no longer a preparatory phase between home life and work life but rather the act of doing work. Buddy worked until late in the evening picking up orders and delivering them to customer doorsteps.

Buddy was severely limited to what internal and external factors he could change because he was bounded by company rules. For example, Domino's gave him a map to assist in delivering pizzas. In the evening when it got dark, Buddy had to resort to his GPS because the map was no longer visible. Domino's has a strict set of guidelines employees must follow. "They stress to us don't speed, don't roll stops, don't do anything [that's illegal]." Buddy's use of his GPS might be considered illegal and possibly violated company policy. While on the clock Buddy complied with road rules such as following the speed limit and obeying traffic signs, this did not align with his normal driving behavior. At one point he mentioned that he had received tickets for rolling through stops in the past. Since Buddy's job directly affected when he drove, where he drove, and how he drove, there was a smaller margin for manipulation of internal and external factors.

Implications

How to Increase Work in the Car: A Mobile Office Model

Working in the car was not a strong theme observed across the nine study participants, but equipping the car with proper tools and technologies would optimize the ability for work. These enhancements would make up the mobile office model of the car, transforming the regular vehicle space into a work-friendly environment. This model, illustrated in Figure 9.1, can be easily adapted to early versions of autonomous vehicles and brought to its fullest potential at level 4 AV.

Figure 9.1. The Car as Mobile Office

A successful mobile office model would include a variety of features specifically for facilitating work activities. WiFi, a work tablet, and hands-free technology are some that would specifically address concerns of the study participants. The WiFi capability would allow reliable internet for checking emails

and connection to work servers with sensitive information. The incorporation of a large tablet would comfortably permit work and study activities. On a very basic AV level, the complete integration of hands-free technology would alleviate the safety fears that prompted participants to create their own rules for devices while driving. However with a level 4 AV, we should consider the additional ability for the hands-free communication system to cancel outside noise. This would prove especially helpful for drivers like Sherlock who have a convertible and enjoy riding with the top down. At the time of the study he pulled over on the side of the road, raised his convertible top, and then answered a client call.

With Level 4 AV technology in mind, other features may be added over time to facilitate additional work activities. For example, in combination with the digital work tablet, we can imagine that a desk of some sort will become useful for conducting work. An easily storable and adjustable desk may be appealing to someone like Sherlock who travels to and from worksites, putting 40,000 miles a year on his car. This desk would include a way to easily connect the tablet for work-related tasks and include a keyboard for reliable computing. Ultimately the desktop set-up could emulate a multi-purpose design with comfortable seating options. Another feature may be additional lighting in the form of a "mobile desk lamp" so that drivers can see what they're working on at any time of the day. Although most documents are digital, a mobile office model should take into account paper products as viable work tools and incorporate their visibility into the design.

Finally, storage options specifically for work may become valuable. External or internal hard drives in the car for work-related material may be helpful for long road trips or commutes. This type of storage may contain sensitive data, so additional security protocols should include encryption packages. At the same time, there may be a need for physical space for work tools. Sherlock stored many of his measuring instruments for crash reconstruction in his trunk, and the items were in complete disarray. The use of his trunk space for work storage limited Sherlock's ability to fill his car with other things that may not be work related. As Chapter 8 discusses, built-in storage units and organizers may become valuable assets to those who rely heavily on their car as a means to and from varying worksites.

Specialized Vehicles for Customer Deliveries

This section refers to Buddy, the pizza delivery driver, who works every Friday and Saturday night delivering pizzas in his own car. The above design implications are irrelevant to Buddy's situation because he uses his car to complete the work task at hand and must abide by company policy. During the driving observation Buddy made it clear that he really liked his job because he made about $300 a week for only two nights of work. However the gain was relative to the cost. Buddy said "the only downside is wear and tear on the car."

Buddy's experience with driving as a part of his job brings forth a relevant question pertaining to AV technology. How will delivery services change? Nissan could partner with companies like Domino's to develop specialized vehicles for customer deliveries. Workers would store their cars and use company vehicles instead. They would be equipped with a warming rack to keep pizzas fresh for customers, a lockbox for money gathered during deliveries, and an enhanced security system. These features would expedite the delivery process and allow more pizzas to be delivered in one outing.

Such specialized vehicles may lead to significant consequences. If Domino's adopted AV technology, there is a possibility that pizza delivery jobs would be eliminated. The only thing left would be to have customers grab their own pizzas out of the car or have a robot do the work. On the lighter end of the scale, employees who now use the specialized vehicles of their employer will lose out on extras such as gas money. Buddy currently makes minimum wage as a delivery driver along with an extra $1.40 for gas

money per delivery. He says that this amount is more than enough to cover gas expenses and contributes to a bigger paycheck in the end.

Enhancing the Liminal Phase: How to Make the Commute More Enjoyable

Making the commute more enjoyable is not synonymous with making a car more suitable for work activities. Some participants, such as Sharknado and Mother Teresa, were not concerned with increasing their work effort while in the car and rather used that time as a preparatory stage during the day. Although some design implications may blend with the mobile office model, this section is dedicated to the creation of a car that best fits the needs of drivers who experience the commute as a liminal phase in their day.

The commuting experience could be enhanced by integrating the removable tablet feature previously described in the mobile office model. Figure 9.2 demonstrates the capability of the tablet to function at home, in the car, and at work. Such a device could be designed with these transitions in mind, allowing drivers to enjoy entertainment or get extra work done before the day begins. An organized control center in the dashboard would give the tablet a resting place while in the car, and would include a multi-media music system. In addition, this control center would be a central place for various devices to be stored, charged, and projected onto the tablet for a seamless transition from home to work. Granting devices their own space within the car would eliminate awkward placement, such as Burrito resting his phone in between his legs, or Leonard propping his phone on the dashboard behind the wheel.

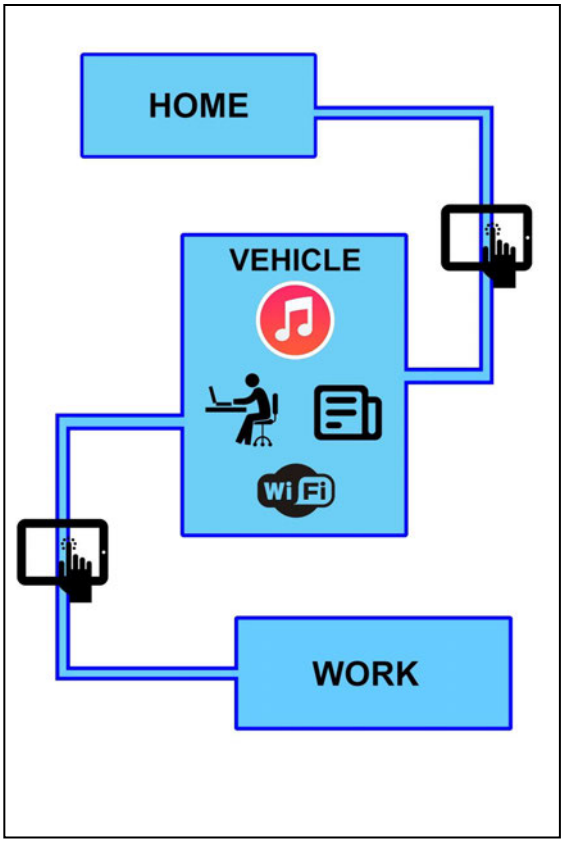


Figure 9.2. Enhancing the Liminal Phase

Beverage machines and an exercise space are also possible implications of using the car as a transitory space between home and work. Sharknado and Burrito were both observed drinking beverages while in their cars. Mother Teresa noted that on long road trips she will stop at a McDonald's for a cold beverage,

and even on her 30 minute commute home she gets very sleepy. Internal beverage machines (coffee or cold drinks) may help commuters wake up in the morning and stay awake on the drive home. Similar logic can be applied to an exercise space within the car. Although this feature will depend on each individual commuter, the car must incorporate spatial flexibility for activities drivers encounter before and after work.

External factors are more difficult to change because they are regulated by forces beyond the control of automakers and drivers. However with level 4 AV, we can imagine an interactive "route calculator" that provides drivers with diverse commuting options. For example, the route calculator could include programmed settings for commutes to work and commutes home. With the help of a hands-free system for simplicity and convenience, drivers would choose which settings are most important, such as scenery and driving time. Commuters could even incorporate commercial routes for completing chores such as picking up dry-cleaning and grocery shopping. At any time the route calculator would allow changes to the settings through a simple configuration with the digital screen or voice command. In addition, this feature would receive continuous updates about road conditions, modifying the route for efficiency while still maintaining the driver's preferences.

The route calculator would greatly benefit commuters such as Mother Teresa and Captain who took efficient highway routes to work, sacrificing scenery. On the way home, both study participants mentioned that they enjoy taking a scenic, less productive route because there isn't as much of a time constraint. Sharknado also attempted to control surrounding scenery so that his commute occurred with the sunrise by adjusting his timing. Other external factors such as train tracks, school zones, and accidents could be easily avoided with the use of a route calculator. Leonard adjusted his route so that he didn't have to go over railroad tracks three separate times during a one-way commute.

In sum, such a design would mimic the fundamental ideas that make up a daily planner. There is nothing in the way of planning a week's worth of activities if your car has the ability to keep a coordinated calendar. Daily commutes would cater to the driver's immediate needs while simultaneously completing as many tasks as possible along the way. This type of adaptability of a commuter route is ideal for those who have to spend a lot of time on the road instead of at home, before or after work.

10. The Utilitarian Relationship Between Cars and Drivers

Logan McLaughlin and Austin Hartt

Research Findings

Our research revealed that people tend to have a utilitarian relationship with their cars. In a commuter culture, cars are seen as a necessity for getting around and, as mentioned in the previous chapter, for accomplishing work and various other tasks. In our society, cars are a tool needed to perform the various activities that make up our everyday lives. However, the relationship that people have with their cars is more complex than one of pure utility, with levels of emotional investment in the car varying from person to person. We observed that a good way to understand the level of personal investment was to look at maintenance practices, cleaning, and overall relationship to the car. In addition to these factors, we analyzed our participants' brand loyalty and financial considerations when purchasing and maintaining a vehicle, which proved to be more important factors than originally thought.

As with most tools, people take varying degrees of care in the upkeep of their cars, and in our research we saw a spectrum of investment. One of the participants, Dr. Pepper, took the utmost care with maintaining her car by using premium fuel, taking it in for regular maintenance, and parking it away from other people to avoid her car getting dented or scratched. On the other end of the spectrum, six of our nine participants demonstrated less concern with keeping their cars looking good and were mostly concerned with the functionality of the vehicle. They were willing to ignore cosmetic damage and neglect making repairs to the body of the car so long as the car still functioned. In addition to this, four of our nine participants were willing to put up with mechanical and functional quirks. For instance, Sharknado was conscious that his car had worn out brakes and thus allowed himself more room to stop. Another example was Captain, who put up with her overwhelmingly loud engine and justified not getting it fixed by informing the researchers that the car "still runs" and could "get here where she needed to go". The value of function over aesthetics in many cases enforced the idea that people see cars as a utility. However, this was counter-balanced by two of the study participants who informed us that a regular maintenance schedule was needed for proper care of the car, as well as regular washing and cleaning of the vehicle, putting emphasis on the car "looking nice".

This raised some interesting questions about maintenance habits. All nine participants expressed interest in the maintenance of their cars to differing degrees. Four of the nine participants reported that either they or an immediate family member were able to do small routine maintenance on the car and in two of those four cases the subjects said that whenever possible they did their own maintenance and that doing so was viewed as an important part of owning their car. Of all of the participants who did their own routine maintenance there were three key components on which maintenance was primarily centered: air filter, battery, and oil. Five out of the nine participants mentioned routine oil changes as part of their maintenance regimen and only two of those five said that they changed their own oil. The primary focus of repairs among all participants was to keep the car in working order, and what qualified as needed maintenance was influenced by the participant's knowledge of the inner workings of their car. People with older model used cars were also more likely to put off maintenance until absolutely necessary

whereas people with newer cars were more likely to take cars in for any maintenance needed. Buddy for instance was a student driving a 2001 Toyota that he and his father had purchased as a "fixer upper" and justified his lack of regular maintenance by saying that the car was "just for school". For seven of nine participants cars were viewed as disposable, without much attachment to the current vehicle. In particular, Sherlock got a new car every six to seven years because for him that was the average lifespan of a car before it began needing too much additional maintenance to keep the car in working order. In addition to this, three of our nine participants, Buddy, Sharknado, and Captain, were students driving older used cars that required a lot of maintenance, who all intended to get newer vehicles once they finished school, but for now needed to keep their vehicles running so they could commute to school.

As stated in the previous chapter, one of the principal uses of cars is for commuting and accomplishing work, but the use of cars and thus the relationship people have to the car goes beyond the commuter task. While eight of our nine participants explained the use of their car in some version of the phrase "It gets me from point A to point B", which epitomizes a utilitarian attitude, the role of the car in their lives was somewhat more complex. On the whole, driving was seen as a necessity by seven participants and of those seven, four cited lack of reliable public transportation as the reason for needing a car. There was no social stigma against public transportation, it was just viewed as unreliable. Our research was carried out in the Dallas/Fort Worth metroplex, where public transportation is indeed much more limited than in urban areas such as New York or Chicago. While driving was seen as a necessity, it was also seen as an enjoyable activity in some cases, with only one study participant, Captain, reporting that she "hates driving". When driving, participants were generally concerned with the efficiency of their route and how it would affect their gas mileage and total drive time. In the case of Lucy, her family utilized their two vehicles, a Toyota Sienna and a Corolla, for different purposes based upon gas mileage. Her family only used the van when they had to transport the whole family, and used the Corolla, which got better gas mileage, when a trip involved a smaller number of passengers. The concern of fuel efficiency compounded with the concerns of overall vehicle maintenance are both driven by a general financial concern of operation cost.

Financial commitment was a pivotal part in both purchasing and owning a car for all of our participants. They all had used vehicles and all of them cited that cost was a key decision in the purchase of a used vehicle over a new one. Despite use of used vehicles, factors such as brand loyalty still played a factor in the decision to purchase a car. Brands were most likely associated with reliability or ease of care. Sharknado's family exclusively purchased Honda vehicles because they had "good experiences" with them. It is also notable that the purchase of a vehicle was often a family decision, with parents helping in the purchase of the cars that their children used until those children were financially stable and able to purchase their own vehicle. For example, Captian's parents helped her buy her car, but the vehicle was in her name. In many cases, this first vehicle was an older model due to low price point and ease of acquisition. Mother Teresa said it was economically irresponsible to buy new cars for kids in college. This was true for all four college students in our study. Used cars also have appeal because they can generally be purchased outright without needing to make payments. Dr. Pepper told researchers that her husband had purchased her car used because it was within their price range, and Mother Teresa said her family bought older cars because they could afford them and did not need to make car payments.

In summary, our study participants valued cars as a utility that was necessary to their day to day lives. As discussed in the previous chapter, a car was a means to do work and a means in most cases for people to conduct their day to day business. This relationship between people and their cars was manifested in the ways in which they used the car for storage, and their personalization of the car as a place where they felt comfortable. However, there was a distinct emphasis on the usability and functionality of the car that in

many cases trumped the way the car looked or the presence of convenient features. This has some interesting implications for the design of AVs.

Implications

The emphasis on utility and the perception of cars as a daily necessity has interesting implications for the design of AVs. Principal among these are the ideas of price point, maintenance and upkeep, and efficiency. People value cars not only as tools that facilitate transportation, but also as a part of their livelihood. This relationship to the car as an extension of their own livelihood guides many of the decisions people make regarding their vehicle. One such implication is that drivers want to have some degree of control over the vehicle. This does not necessarily refer to driving; it can refer to customizing the vehicle as a personal space, as discussed in Chapter 6. Control may be exercised in some cases by an ability to care for the vehicle and ensure it is in operating condition. Captain for instance wanted "the freedom to fix or screw up [her] car". While the complexity of computing necessary for an AV to function properly means that there should be minimal interaction between the car owner and the car computer, there needs to be a compromise of what the driver can access. Perhaps the driver could access the battery, oil, and air filter. These kinds of basic routine repairs and access to various other small maintenance features would allow the driver to exert control over the car without necessarily jeopardizing the security of the complex computing systems needed for the successful operation of AV systems. This concept is demonstrated in Figure 10.1, on the following page, which demonstrates a possible way in which drivers could access certain maintenance features of the vehicle without needing access to the systems governing the vehicle. This sort of screen could display upon startup and let the driver know the status of their car.

To compensate for the closed off nature of the complex systems of an AV, one possible consideration for users is the presence of a self-diagnostic system within the vehicle. Such an interface, pictured below, could give the driver a more useful summary of the current condition of the engine and systems of the vehicle in a way that is more transparent than the check engine light found in current cars. The interface could also provide greater detail on specific components of the car or be set up to give the driver reminders about oil changes and other routine maintenance. This would allow the driver peace of mind and a greater understanding of when maintenance needs to be performed to facilitate the best functionality of the vehicle and keep the driver informed of the condition of their car. The kinds of compromises mentioned in the previous two sections may also help to ease the transition between the levels of AV by giving the user a sense of autonomy over the care of their vehicle. Though theoretically, at Level 4, this kind of technology could be networked and the car could take itself for routine maintenance, and inform the owner of what maintenance has been performed and keep a log of repairs made. This sort of functionality could also facilitate more reliable sales of used vehicles with a complete history of repairs.

This sort of diagnostic on-board computer could also be used in route finding and planning of energy efficient routes to minimize drive times. And plan routes that include charging stations or other necessary services or stops. While this may only be a minor expansion of current GPS technology, incorporating it into AV seems to be a logical decision. In addition to this, a quantifiable display of both energy efficiency and economy would meet the desire of users to have a clear idea of the fuel efficiency of their route. Tracking fuel efficiency could be related to the modular parts to customize the interior of the car described in previous chapters. The computer could track how the inclusion of certain items or features would impact the overall efficiency of the vehicle.

One other big implication from a design standpoint is the study participants' emphasis on the design of the interior of the vehicle. Our research revealed that for the most part, the outside of the car does not matter as much to drivers as the interior space of the vehicle, and it is far more likely that people will

personalize the interior space of their cars than the exterior features. For this reason, more emphasis should be put on designing the interior space of an AV than the design of the exterior, at least based on the findings of this study.

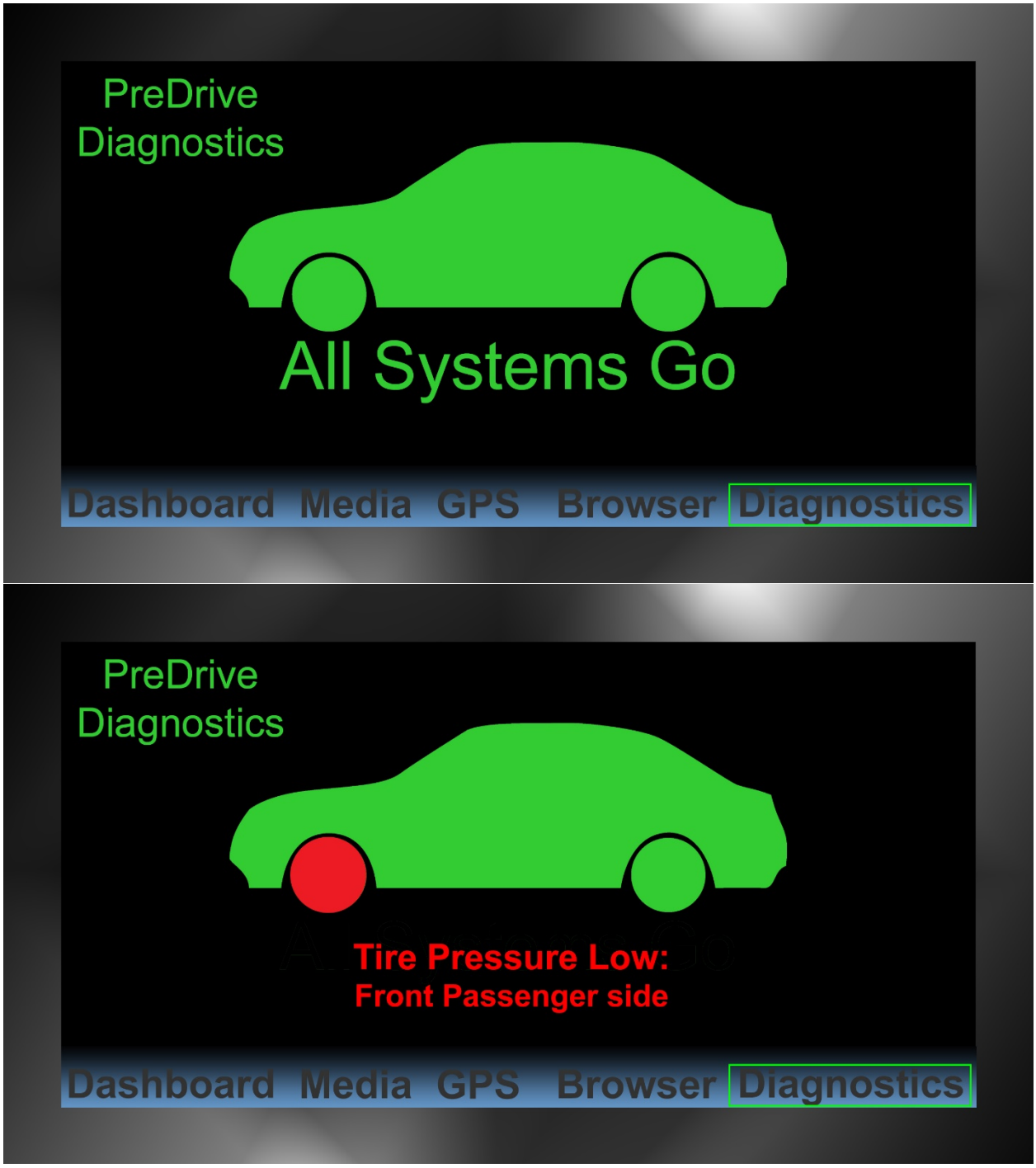


Figure 10.1. Self-Diagnostic System Interface

The Rental Model

One of the biggest implications of a utilitarian attitude toward cars concerns the rental or car-sharing model that AV developers are considering. If people do not have strong emotional attachments to their car, and are focused more on cost, they might welcome a car-sharing program. On the other hand, most of our study participants did not think highly of public transportation, and preferred having ownership and control over their primary means of transportation. Car-sharing programs also conflict with the findings in Chapters 6 and 8. Users of such programs would no longer be able to develop mental maps of their customized arrangements of objects stored in the car. Chapter 12 considers the rental model in more detail.

However, our research did not directly address how people use public commuter transportation systems. For insight on this topic, we recommend a study on commuter trains or other types of transit in which people do not have the personal investment that they do in the space of a car. Or a study on business people who travel frequently and make frequent use of rental car services. While the rental model is an interesting proposition, more research is needed to properly understand the design implications needed for a rental or public use AV.

Ideas for the Future

11. Study Participants' Perceptions of Self-Driving Cars

Tyler Brickle

This chapter presents our study participants' perceptions of self-driving cars. It summarizes what participants said about AV, what they would like or dislike, and what they would do if they had AVs. Their responses will be discussed based on the different levels of automation. The comments by research participants were both positive and negative, as well as offering insight into design implications and areas for further research.

Overall, the study participants seemed to be cautiously optimistic about AV. They recognized advantages, such as being able to engage in other activities during a drive. At the same time, they were concerned about the potential dangers of an AV not responding adequately to an emergency, or failing to complete important routine tasks like closing the garage door. All study participants wanted to be able to take over control of the car in an emergency situation. Most also wanted to take over the controls for the occasional enjoyable drive.

We should note that what people *say* they will do is not always a reliable indicator of what they will *actually* do. Also, questions about AV were not originally part of our interview guide, so only five of our study participants were asked about it.

A complete list of study participants' comments is provided at the end of this chapter.

Partial Automation

Study participants made a number of comments about features they would enjoy having in a car that was somewhat but not fully automated (corresponding to NHTSA Levels 2-3). The two most common things that people wanted automated were acceleration and steering. Three research participants suggested that having the car move them along in a traffic jam would be nice. Three participants agreed that this would give them more time to relax, check emails, send messages, respond to social media and even watch TV. One participant suggested that there would be many social implications of a self-driving car as it related to road trips. Two participants mentioned that they would sleep if they did not have to drive the car, while two participants were more hesitant to sleep.

People also posed questions related to AV. Some of the major concerns and questions were whether or not they would be able to take over the car if something happened, or just for the fact that they want to drive. They also wondered if they would be able to trust the system 100%, and if it would take the route that they wanted. These questions lend themselves to areas for further research or things to consider when developing AV technology.

Full Automation

Although Level 3 and 4 seem to have some cross over, there were only two participants who suggested something that would fit exclusively into Level 4. One participant suggested that it would be great if the car could take itself in for repairs. Another one liked the idea that you could call the car to come pick you up, for example if you were at a bar and needed a ride, but feared that if her car was in the garage and she called it to come get her, it might forget to close the garage door. She did not fully trust the AV.

Complete List of Study Participants' Comments about AV

Below are summaries of all the comments our study participants made about AV.

Buddy

If he was given a choice to be in a car that was fully automated, he would sleep. If he doesn't drive, he sleeps.

Burrito

He says "the autopilot thing is not fun."

Burrito does not feel he would sleep because the car is "like a computer" and if something goes wrong you need to be alert.

Burrito says that such automatic features would be good because he can do other things or if he is tired he can just sit there and relax.

Burrito says he would play on the phone. He says he would check notifications and send messages. He says he might watch something if he had a screen.

Captain

She understands the importance of a manual override in case of emergency or if she ever wants to drive.

The subject of self-driving cars came up naturally, which allowed us to ask some good probe questions about self-driving cars since Captain was already familiar with the subject.

Captain is excited about self-driving vehicles but wants to be able to work on her own car and take care of it, she would like for there to be a system diagnostic feature that she has access to in a self-driving car.

Captain has a vested interest in self-driving cars because she hates driving and believes they would make her life easier.

A self-driving car would give her time to study, check emails, watch TV or other media, talk on the phone in a more relaxed manner she clarifies that she can talk on the phone while driving but has to be more careful and if she didn't have to worry about paying attention she could be more relaxed.

We go on to discuss the implications of self-driving cars on road trips and making the drive half of the sightseeing of the trip. Captain responded excitedly to this idea offering up many possibilities of the social implications of a self-driven road trip and being able to sleep on the go.

We suggested the idea of a car being able to take itself in for repairs and she responded with an overwhelmingly positive "That would be so cool" saying that it would be helpful and she could do other work instead of managing her time.

She reiterates that she hates driving, because it's stressful and people don't know what they're doing; she gestures more frequently with her hands She knows about Google's project in California and can't wait for self-driving cars. This was an aside that occurred naturally.

We then asked some questions about the features of a self-driving car she would like and what she would be hesitant of. She responded that she would "love" a self-driving car, but that it would need to be able to sense things so that it could be safe, although she admits not knowing how this would work.

A system diagnostic upon start-up is another feature she mentions that checks the car's engine.

Dr. Pepper

How would you feel if you were stuck in traffic, but didn't have to worry about driving—the car would do it for you?: "It's still annoying that I have to be stuck in traffic and have to waste my time. But it would be better if I don't have to drive, because when you're in traffic you have to drive little by little and that's kind of a lot of work."

Could you be able to call the car to come pick you up? For example if you're at a bar and you need a ride? What effect would this have on taxi services?
Dr. Pepper thought that would be really cool, but feared that if her car was in the garage and she called it to come get her, it might forget to close the garage door. She said she would still doubt it.

She wanted to know if everyone had self-driving cars, if there would be need for driver's licenses. She expresses her discontent with the DMV.

Dr. Pepper says she's be willing to try the self-driving car, but wanted to know if she'd be able to take over driving if she wanted to. She thinks that sometimes it would be nice to be able to drive.

When asked about how other people would react to self-driving car, she said she didn't know about others, but she wouldn't be able to trust it 100%. She doesn't think it would be safe. "What if the car doesn't do something it's supposed to or…take a route I don't want to go."

Dr. Pepper thinks the self-driving car would need to be very smart and not pick up on talking to her friends as a command. A button should be pressed first before the car recognizes a command.

Sharknado

Sharknado thinks it's a cool idea, but only assuming the technology is there and advanced enough to where he doesn't have to worry about accidents, getting lost, or other malfunctions.

"I just don't have that mindset yet, I haven't been exposed to that world of self-moderating cars." Would be helpful with his long commute, especially when driving back at night when he's tired.

12. Modular Pod Concept

Chris Ferrell

In this closing chapter, based on key findings from our study, we propose a modular pod concept for consideration in autonomous vehicle design. This concept modifies and extends the idea of car-sharing programs as they have been discussed in the AV literature (Anderson et al. 2014). Our modular pod concept resolves contradictions between findings from our study that support the viability of car-sharing programs, and other findings that reveal potential problems with car-sharing.

Car-sharing programs are supported by the findings in Chapter 10: our study participants generally had a utilitarian attitude toward their cars. Cost and reliability were more important to them than emotional attachment. We believe people would be receptive to car sharing programs as a way of saving money.

Potential problems with car sharing were revealed in Chapters 6 and 8: people value their ability to personalize their vehicles, allowing the interior *space* to become a *place*. Our participants regarded the interior of their vehicles as a place with personally relevant significance. Furthermore, drivers developed embodied knowledge and mental maps about the locations of various car features and objects in their car. These mental maps helped drivers locate the items they needed quickly and efficiently, often without needing to look at them. We believe people would resist car sharing programs because they would lose the ability to personalize and customize their space.

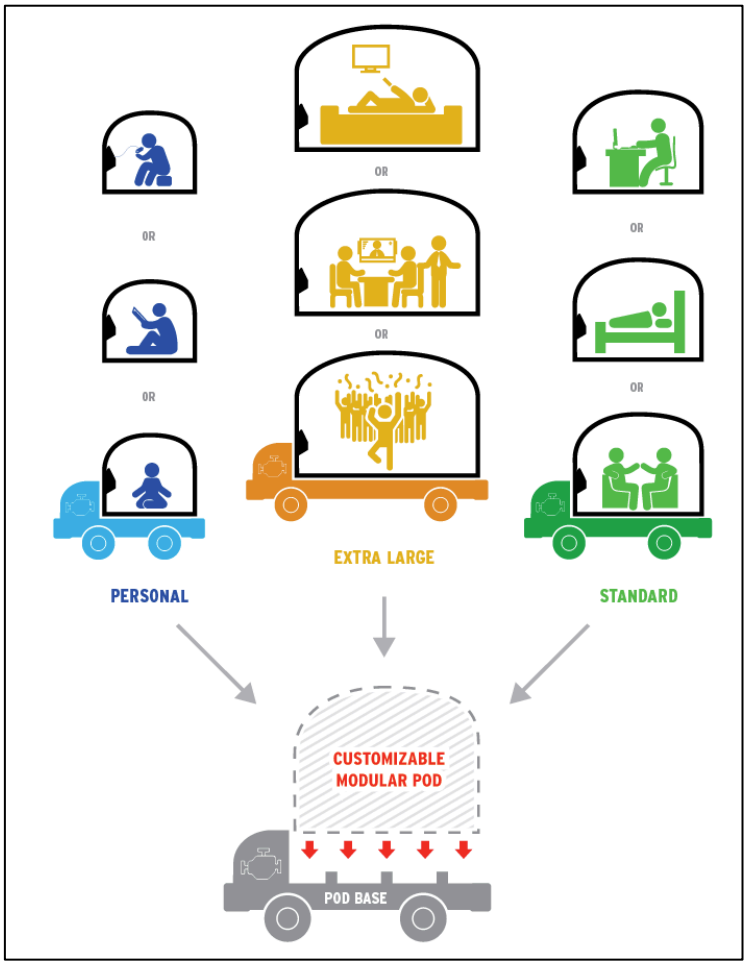


Figure 12.1. Multiple Possible Pod Configurations

In class discussion, we developed the modular pod concept as a way to resolve the contradictions between these two sets of findings. We envisioned interchangeable modular pods that could be attached to any number of bases. The modular pod concept separates the AV into a privately owned customizable pod and a universal community base. This would preserve the owner's ability to personalize and customize the space in any of three basic detachable pod layouts. The variation of pod type would largely be based on capacity requirements. The appropriately matched bases would remain universal

and impersonal. Figure 12.1, above, demonstrates the various configurations.

Existing Car-Sharing Programs

Companies such as ZipCar, RelayRides, and GetAround are vehicle rental services that employ different rental models. ZipCar is a company that owns a fleet of vehicles in the traditional sense, but rents cars by the hour instead of by the day for a more locally focused service. The other two models are web-based networks that allow vehicle owners to list when and where their vehicle will be available for rent. Community resource sharing via rental models such as RelayRides and GetAround attest to the viability of such arrangements. Linking AV to the modular pod concept in the form of such a rental model, could promote a significant cost-offset facilitating a more rapid transition toward a uniform AV environment.

Historical Precedents for this Concept

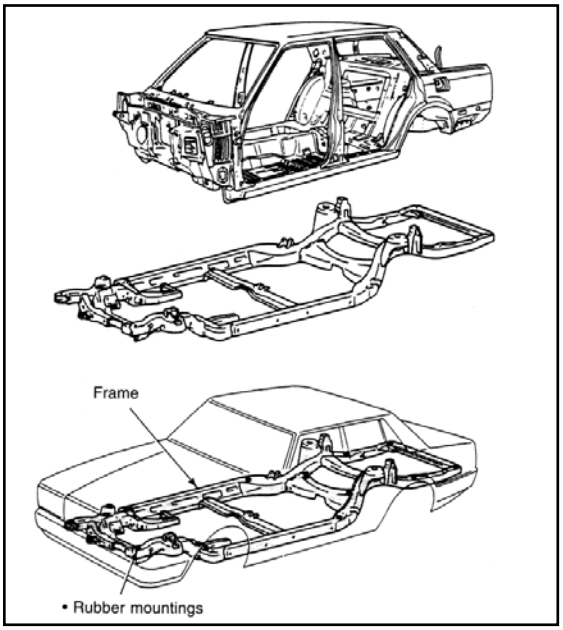


Figure 12.2. Body-on-Frame Design (Robinson and Livesey 2013:32)

If vehicle design returned to the body-on-frame construction that *preceded* the unibody construction now more widely employed by auto manufacturers, the idea seems more plausible (Robinson and Livesey 2013). Figure 12.2 illustrates this body-on-frame design. When unibody construction was adopted, its benefits were lighter overall vehicle weight and the development of "crumple zones" for distribution of force upon collision.

However, within a new AV environment, collisions are anticipated to be far less likely in terms of both frequency and severity (Anderson et al. 2014:xiv). This would further allow the construction of AV's with lighter materials. Revisiting design requirements conducive to the AV environment may be warranted. In our modular pod concept, shown in Figure 12.3 on the next page, the *base*, to include the frame, wheels, and motor, would connect to, or detach from, the *pod* upon departure or arrival.

A similar example exists within the trucking industry where there are easily three times as many trailers as there are tractors to pull them. For AV, there would be more pods, and fewer community bases.

Financial and Safety Benefits for Users

We envision a financial model where consumers purchase their pods, but then employ a type of pay-per-use system for the base. One advantage would be that people would pay less for their initial AV, which would speed up the adoption of AVs. More rapid adoption of AVs, in turn, may yield life-saving benefits. This would be similar to the fielding of seatbelts, which had a marked effect in reducing deaths and injuries from motor vehicle crashes, as noted in an NHTSA study (Blincoe et al. 2014).

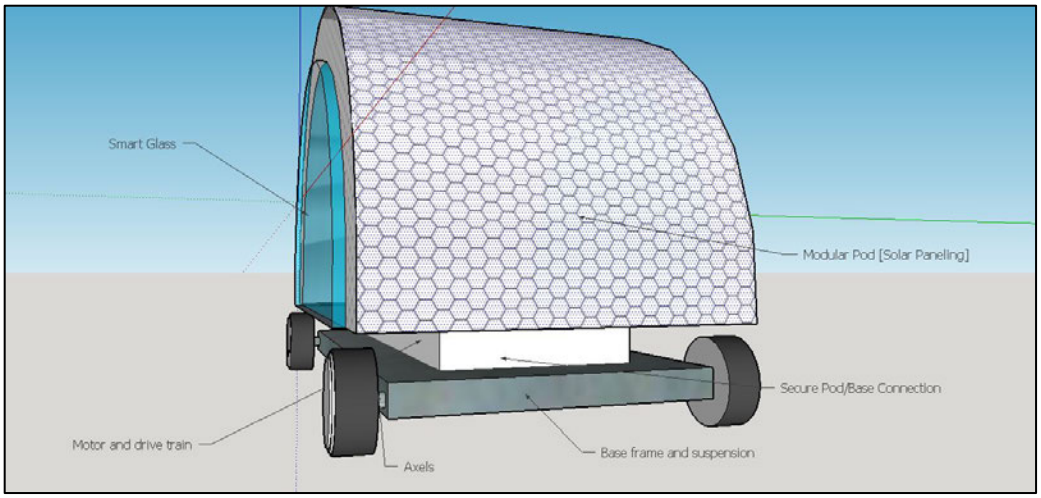


Figure 12.3. Key Design Aspects of Modular Pod Concept

Multimodal Pods: From Roads to Trains to Homes

The processes involved with pod detachment or attachment present a new issue. This could likely be overcome with solutions that integrate the pod further into newly designed homes, which have built-in "receivers" for pods, allowing the AV base to remain in service for other commuters. Picture the scene in the 2002 film *Minority Report* where the AV delivers actor Tom Cruise to his home, creating a seamless transition from his car to his living room. This idea could be further extended to longer distance travel on trains, where the commuter's pod is detached from its base and occupies a portion of a train car along with other "pod commuters", met by other available universal bases at their destination, accommodating transportation over longer distances that may be out of reach for fully electric AV's. This means the pod becomes *intermodal* or *multimodal,* able to transition from one mode of transportation to another. In this example, from the universal base to a rail car. Similarly, with receivers at private residences, the pod then becomes another space attached to the home.

Modular Components for AV Interiors

Chapters 4, 5, 7 and 9 describe the many activities that drivers already engage in, other than driving itself. These activities are likely to increase significantly with the adoption of AV. In this final chapter, we build on the implications for AV design described in those earlier chapters, and offer a final vision for how the interior of an AV might support the various activities of its occupants.

We propose the idea of a modular interior design. The front seats of AVs need not be fixed in the forward-facing direction. Allowing the seats to rotate on their vertical axis would facilitate personal communication within the vehicle. The ability to add or stow seats, tables, or smart-glass interfaces will allow a degree of customization for consumers. Modular components will permit the user to arrange their

vehicle in a variety of ways. Figures 12.4 through 12.6 show an arrangement with a central table that would support various kinds of social and work activities.

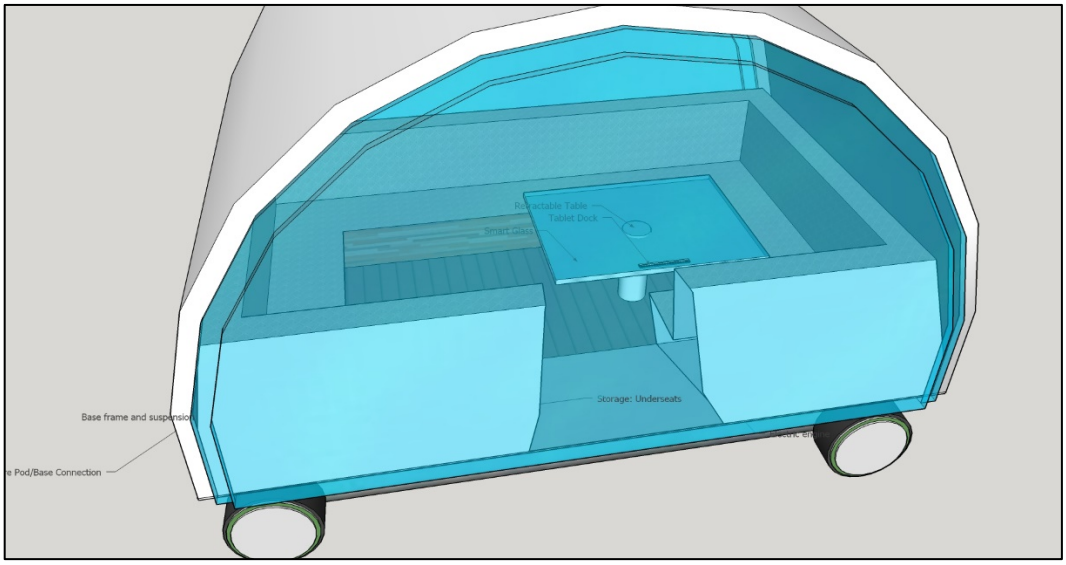


Figure 12.4. Interior Design with Table

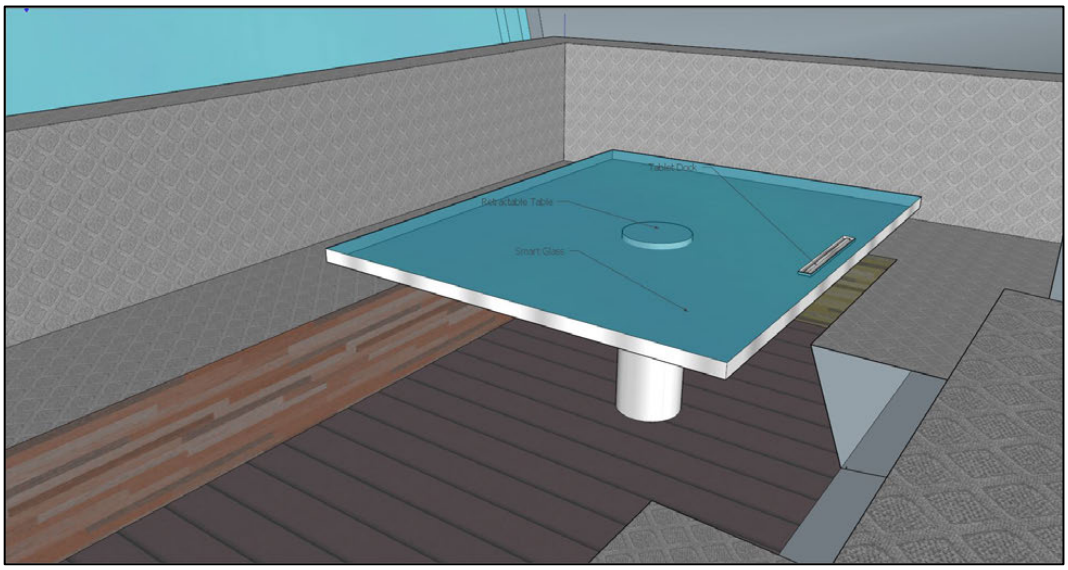


Figure 12.5. Close-Up of Interior Design with Table

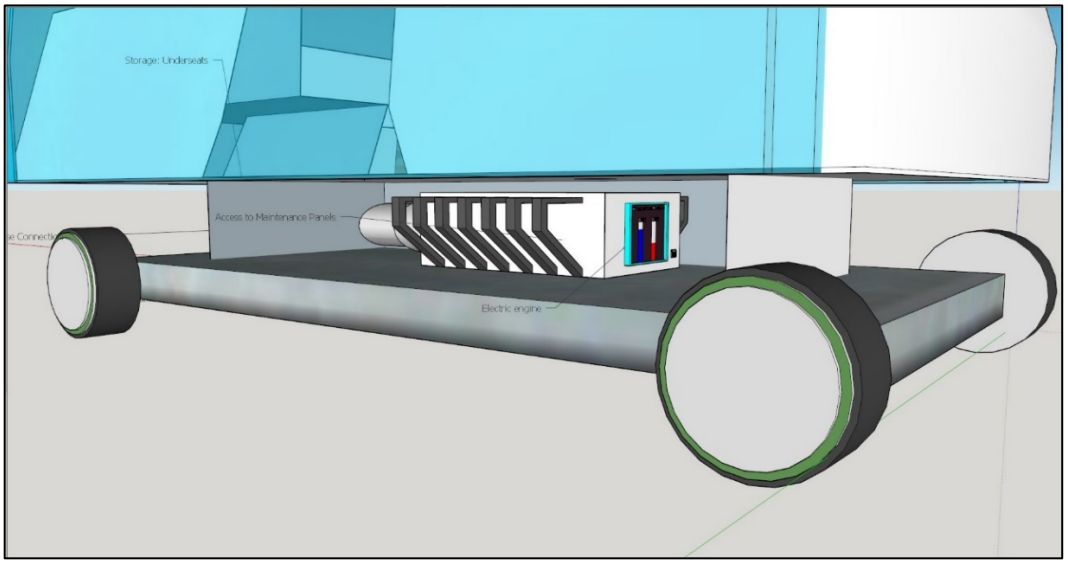


Figure 12.6. Bottom of Pod and Base

Conclusion

The development of AV technology is moving forward at a rapid pace. Ultimately, however, consumers need to be willing to adopt AVs in order to make this new technology a success. By investigating how people are currently using their cars, our study identified implications for how AVs can be designed to promote their adoption by the consumers of tomorrow. Consumers will be most likely to use AVs if the vehicles support their needs, values, priorities, and car-based activities.

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