UNDERSTANDING ROAD USE AND ROAD USER INTERACTION: AN EXPLORATORY
ETHNOGRAPHIC STUDY TOWARD THE DESIGN OF AUTONOMOUS VEHICLES

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This thesis contributes to research that informs the design of autonomous vehicles (AVs). It examines interactions among various types of road users, such as pedestrians and drivers, and describes how findings can contribute to the design of AVs. The work was undertaken as part of a research internship at Nissan Research Center-Silicon Valley on the Human Understanding in Design team. Methods included video ethnography “travel-alongs” which captured the experience of travel from the point of view of drivers and pedestrians, analysis of interaction patterns taken from video of intersections, and analysis of road laws. Findings address the implications of what it will mean for AVs to exist as social entities in a world of varied road contexts, and how AVs might navigate the social act of driving on roads they share with a variety of human users. This thesis contributes to an emerging body of research and application on the subject of the AV in the world.
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CHAPTER 1

INTRODUCTION

1.1 The Dream of the Self-Driving Car

The dream of a self-driving car, or as it is often referred to in the auto industry, an autonomous vehicle (AV), is not a new one. In the United States, the dream of new mobilities can be traced back to the 1925 with the Linriccan Wonder, the first radio controlled full sized vehicle (Mills 2015). Radio controlled car technology was demonstrated again at the 1939 World’s Fair Futurama exhibit. In the technology boom following World War II, there were more substantial advancements in the concept of autonomous vehicles (Mills 2015). Since then the autonomous vehicle has become a staple of science fiction and engineering alike. Notions of smart cars and smart roads seem only fitting for what Walt Disney called “a nation on wheels” in his World of Tomorrow television series, which aired in 1958 (Kimbball 1958). In an episode of that program entitled, “Magic Highway USA,” Disney gave a history of the road and of mobility in the US. The episode included a segment of what some would call outlandish ideas for the future of mobility, such as the portable car and disposable highway vehicles. The program also included other, more realistic, ideas such as the rearview camera and lastly the self-driving vehicle that requires “no driver responsibility” (Kimbball 1958).

However, Disney is not the only one to have produced ideas about future mobility in the 1950s. General Motors (GM) showcased a variety of ideas on “The Future of Driverless Cars” as part of their Key to the Future series which aired between 1955 and 1960. This show featured their Firebird II concept vehicle, described as having an electronic brain. In 1956 GM proposed
the idea that driverless cars would be controlled remotely by a tower that would set cars on predetermined routes to their destination when auto-control was initiated via an electronic control strip in one lane of the highway (General Motors, 1956). This vision raises two issues that are still of concern to designers and engineers today: (1) the range of operation for AV and (2) the possibility that AVs may need to be separated from other vehicles on the road for the sake of efficiency and safety.

In the earliest days of the AV dream, radio control seemed to be consistently relied upon in thought experiments related to vehicle autonomy. It was not until after the advent of personal computers that the concept of artificial intelligence in a vehicle really took hold. This idea of artificial intelligence (AI) resulted in what we would think of as perhaps a more modern iteration of the idealized AV. A prime example of the AI controlled AV can be seen in William Gibson’s 1984 book *Neuromancer*, wherein a Mercedes car drives the protagonist through Istanbul and acts not only as a form of transportation, but also as a tour guide. This car, described as “the Mercedes,” is only mentioned in brief. Despite its brief appearance in the book, the Mercedes has all the elements we would expect from an AV. The car avoids obstacles in the road, takes destination requests, navigates the city, and when all is said and done, parks itself (Gibson, 1984). This depiction of an AV, not as a focal point, but as an element of the setting, indicates to the reader the near-future time in which the book takes place. The interpretation is in some ways a more realistic vision of AV than the over-engineered driverless cars presented in the 1950s. It also demonstrates another interesting facet of the dream of AV that we have seen propagated even into modern science fiction. That facet is that driverless or autonomous vehicles are a logical progression from current technologies.
Science fiction tends to influence fields of science and engineering, and the world of automobiles is no exception to this. Examples mentioned above are selections from history that demonstrate but do not belabor this point in reference to AVs. Gibson’s version of the AV in particular resonates with the work of this thesis project. The Mercedes in *Neuromancer* demonstrates a familiarity with the area as indicated by its ability to serve not only as a mode of transportation, but also as a tour guide. Local familiarity became a point of interest in this investigation. The idea of an AV becoming local and how to facilitate its localization is something that has only appeared in the pages of science fiction. So, how then do we go about designing these future technologies—making a dream a reality? As anthropologists, our part to play is to research the ways in which these new technologies integrate with people, especially in the complex human-road system. While the AV itself could be considered a dream come true, it is an unknown agent being introduced into a chaotic system that is by no means perfect. Understanding how humans can work with this technology rather than being disrupted by it is key to a smooth integration of this technology into our everyday lives.

1.2 Where We Stand Now

The dream of the AV is one that is very close to fruition; this year Google expanded their testing of autonomous vehicles from the Mountain View California area to the Austin, Texas area. Tesla vehicles can now autonomously drive in several contexts including highways and some limited urban driving. Many mainstream auto manufacturers including Nissan have announced their concepts for AVs (Forrest 2016). Currently, the move toward AVs seems
almost inevitable. Engineering is a positivist paradigm and progress marches on toward the creation of AVs.

The investigation discussed in this document took place at the beginning of the study of AVs and how they might interact with other road users. The aim of the investigation was to help design AVs that could be more easily integrated with current driving practices. What makes this sort of investigation difficult is that we cannot study AVs as they exist. We can however study road use and road user interaction as they are today. Studying these topics can inform further study of the usability, sociality, and integration of AVs as new road users into the human road system.

Since there was little precedent for this kind of study, the investigation relied on a multitude of methods employed in succession. Due to the context of working in a Silicon Valley research lab, the methods employed for this study were designed as an exploratory first thrust into potentially fruitful areas that might subsequently undergo further investigation. It is also due to this set of methods that the findings of this study identify general implications of designing the AV for use in the human road system, rather than focusing on one particular area, such as interactions between drivers, prediction of road conditions, or navigation. This paper serves as a foundation for beginning to understand how we, as applied anthropologists and designers committed to user-centered design, may study the autonomous vehicle.
1.3 Description of the Internship

This project was undertaken as part of a research internship at Nissan Research Center-Silicon Valley (NRC-SV), a small research oriented branch of Nissan Motor Company. The Silicon Valley branch houses research and developmental divisions for both Nissan and Renault, who are currently in a developmental partnership. NRC-SV also works in conjunction with the Nissan headquarter’s research groups in Japan. NRC-SV is a multi-national research environment with individuals in fields ranging from computer science to mechanical engineering, and applied anthropology. This diversity created a dynamic work environment and an incubator for new ideas and mobility concepts to be implemented in the near future. The focus on the near future is what separates NRC-SV from Nissan’s Future Lab, another research division within Nissan focusing more on concepts far in the future.

1.4 The History of this Project

The origins of this study begin with a project undertaken by Dr. Christina Wasson’s Design Anthropology Class at the University of North Texas. The Social Life of the Car project was the gateway to an internship and ultimately led to my own thesis work with Nissan. The Social Life of the Car project was organized by Dr. Wasson and Dr. Brigitte Jordan who, at the time, was working as a consultant for NRC-SV. The aim of the project was to gain an in-depth understanding concerning the meaning of the car in the social context of everyday life. The findings of the Social Life of the Car project revealed the car and the experience of driving to be incredibly embedded and culturally situated behaviors. At the time of writing, those behaviors had not been well studied from an anthropological perspective. Due to the research Dr. Jordan
had conducted at NRC-SV and the results of the Social Life of the Car project, NRC-SV hired anthropologist Dr. Melissa Cefkin as a full time researcher and formed the Human Understanding in Design (HUD) Team. I was hired by NRC-SV as a summer research intern in 2015 to help the lab conduct design-oriented research; my work there forms the basis of this thesis.

1.5 The Focus of the Investigation

The HUD team’s work included designing research methods to gain insight into issues with possible AV testing and implementation that they, and other groups at NRC-SV, identified. Prior to my arrival, the team identified road user interaction and a possible problem area. The team is also responsible for proposing actionable data-driven solutions to problems which included prototype concepts. For the purposes of the thesis writing process, this applied environment created an opportunity to hone my skills in the real world. Due to the applied nature of the thesis project, conducting research as part of an internship was an especially valuable component in preparing me for life after graduation.

Initially, the central focus of the HUD team was to better understand road user interaction at intersections, particularly at four-way stops. Anthropologically, the aim was understanding the social and cultural norms of interaction between various road users, and how these rules and norms are learned, situated in, and ultimately impact day-to-day travel. The end goal of their investigations was to create systems to better facilitate interaction between AVs and other road users. Thus, the original aim of the HUD team’s research was
understanding the nuanced social rules, interactions, signals, gestures, and courtesies we commonly use to navigate four-way stops. This goal was determined prior to my arrival, and a significant amount of data including the data regarding intersections discussed later in this thesis had been collected by the time I arrived on site. While this original topic remained an important part of the HUD team’s investigations, the focus of our research slowly shifted to a more holistic understanding of the road and how road users interact in a broader sense and beyond intersections specifically. The evolution of these goals and aims occurred in tandem with the design of the travel-alongs and further analysis of the intersection data.

During the course of investigation, questions organically grew out of our initial analyses of the data collected before my arrival and of the data collected while I was present. This organic process of exploratory investigation also generated more questions for further research. These questions led us to identify situations in which an AV might struggle or encounter problems that would be outside of its programming. In addition to investigating these possible problem areas, I also worked on concepts for external Human-Machine Interaction (HMI) systems for the AV. This work investigated communication systems on the outside surface of AVs that potentially help AVs interact and communicate with other road users.

In a more general sense, this work comes at a very interesting time in the development and eventual market release of autonomous vehicles. Google could be considered the industry pioneer in pushing the AV to market due to their public pushes for extended AV testing. However, at the time of writing, many vehicle brands including BMW and Tesla offer vehicles with semi-autonomous modes. Thus at this juncture, many auto manufacturers are working on
autonomous prototypes. The industry is at a pivotal point in the development of AV technologies, and as with most new technologies, now is the time to bring in not only the human perspective, but to create technology that better serves users.

1.6 Objectives of the Applied Project

The research of the HUD team sought to better understand the human factors related to a future with autonomous vehicles. We sought to grasp possible usability and integration issues of AV concepts, not only in their physical form, but also in their execution, introduction to public roads, and their behavior. The challenge we faced lay in trying to determine the usability of concepts without having something concrete to reveal to participants or have them interact with. The challenge of working with concepts also presented one of the greatest opportunities of this research. Because we dealt in the hypothetical and abstract we were able to solicit ideas from participants without the constraint of a physical prototype or functional entity. The aim of the HUD team was to attempt to understand and codify current driving interactions so as to create a usable prototype of AV interaction and concepts that would meet the needs of end users, in this case the general public. In a practical sense, this meant continuing to examine and understand the experience of travel and how people experience road use.

Because this project was undertaken as part of an internship, the deliverables took the form of small reports and a final presentation of my work with Nissan. The collection of internal reports was published on an NRC-SV wiki page for internal use, while the final presentation was
presented at a weekly “all hands” meeting. These meetings consisted of everyone in the office sitting in on a presentation from one or more departments or individuals on current projects. While my reports on the research as well as the side investigations added valuable insights to the Nissan wiki, my final presentation had a far more profound impact on the office as a whole. Showcasing the idea of the AV as local was definitely a notion that stuck with other teams at NRC-SV.

My project makes up only a small portion of the research being conducted in the automotive industry today. As we move closer to the dream of AV, more car companies are beginning to bring designs into the world. NRC-SV has a vision of the AV existing in the world as a social entity just as much as an entity of transportation. It is for that reason that Nissan employed ethnographic methods in trying to design the best total experience of AV for the end user. In order to better inform our research, we looked into the existing wealth of information available in the literature relevant to our project. Utilizing a wide variety of literature from design, anthropology, usability, and transportation studies, we were able to ground our research in current and relevant theoretical and methodological frameworks.
CHAPTER 2

RELATED LITERATURE AND THEORY

There is a paucity of anthropological literature on the subject of the automobile. Much of the research on cars and the built environment comes from a multitude of disciplines outside of anthropology. This chapter reviews a cross section of this literature and highlights the main theoretical frameworks that influenced this project.

2.1 Design Research Literature

Design is not a new frontier for anthropology. Technology continues to permeate our daily lives; the place of anthropology in design is ever more important to create and ensure the development of products and technologies that work with people rather than against them. To some degree we must alter Weber’s classic definition of humanity being suspended in a web of significance, to humanity being suspended in a web of technologies of their own creation (Geertz 1973). We are at this point hybrids of human and technology, veritable cyborgs, intertwined so intimately with technology that it has become an extension of our natural faculties (Case 2011; Selinger and Engstrom 2007). It is because of this phenomenon that a praxis-oriented research approach to the interaction of humans and technologies is valuable. Phenomenological theories of equipment and prosthesis form the background to the research approach employed in my work (Arnold 2003; Heidegger 1998).
Design anthropology as a discipline owes much of its roots to the efforts and work of the researchers at Xerox PARC in the 1980s and the work of such pioneers in the field as Lucy Suchman and Brigitte Jordan (Wasson 2000), the latter of whom I had the privilege of working with on this project. Suchman’s work on “making work visible” serves as a good foundation for the research (Suchman 1995). Suchman’s central idea of making the mundane activities of users visible is ultimately still a guiding principle of ethnography in design. This work also pulls heavily from the methods of interaction analysis refined by Jordan and Henderson. Interaction analysis allows for the inclusion within ethnographic data of the more nuanced gestures and behavior that permeate daily life through the use of video recording (Jordan and Henderson 1994). One of the key methods is participant observation in environs not traditionally seen in anthropology, such as the corporate world or the societies within which we ourselves are embedded. However, design anthropology is also built upon design and psychology as much as traditional ethnographic methods and theories.

In terms of design philosophy, this project posed a complicated question: how to conduct ethnographic research to design a large-scale human-machine interaction system that does not yet exist. Unlike other projects of design that may build on current models or improving existing products, we were working with an end product which has no real precedent. Most people have no frame of reference for an autonomous vehicle because they have never interacted with one. When working with our design ideas we had to expand our theoretical view beyond the scope of Silicon Valley where AV testing is already commonplace. We needed designs that could work just as well in suburbia as they could in an urban space and were just as easily understood by aging populations as by young technocrats. Fortunately, even
in this scenario, the methods of design ethnography and the ethos of user-centered design were still useful in creating actionable design ideas for AV interactions.

Don Norman (2007) gives some good insight on user-centered design relating especially to AVs. In the end, the user must still be in control. The idea of user control and agency is a basic element of user-centered design and should not be overlooked. The logic of human-centered design implies that we involve the users in the design process and try to impart to them a clear idea of the function of the proposed system (Maguire 2001). In the fast-paced development cycles of the technology world, ethnographic methods related to human-centered design have adapted to be faster, but just as intensive. This paradigm of speed gave rise to rapid ethnography which is often embedded within AGILE or lean design methods (Millen 2000, Chamberlain et al. 2006). However, even within these fast, lightweight methods of ethnographic research there is a finesse to the speed and a limit to what can be done in a short amount of time (Cefkin 2012). More so than ever, striking the balance of speed and quality is important to an ethnographic project. User-centered design may have been a theoretical backdrop for our method in general terms, but for this project we needed more than what these theories would provide. To gain a full picture of the road and its users there are far more specific elements that were needed.

2.2 Automobilities and the Built Environment

In order to better understand the road and mobility as a linked and holistic system, I drew on the field of transportation studies. AV developers often regard AVs as one piece of a
broader vision of a sustainable future that includes an overhaul of the urban transportation system. This viewpoint has emerged in a variety of urban contexts including the San Francisco Bay area. In an urban design sense, this can be referred to as Transit Oriented Design (TOD), which decreases overall dependence on driving (Chowdhury 2014; Bevilacqua et al. 2013; Goldman 2013). This approach advocates the design of built environments with easy access to transit, creating a sustainable environment. Another factor contributing to ideas of future transportation and mobility development is Initiative Zero, a transportation philosophy that began in Sweden advocating for zero fatalities on roads (visionzeroinitiative.com). This philosophy of zero fatalities influences much of transit and transportation studies literature; this includes autonomous vehicles and driver assistance to make cars safer. Initiative Zero has shaped much of transportation thinking and discourse in terms of urban architecture and design and even traffic laws, but for the most part this ideology has had only a cursory influence on the actual study of vehicles.

In the academic literature on transportation, studies of vehicles have led to studies of who owns cars, and how people navigate urban environments (Habib 2014). Factors that transportation studies investigates include differences in socioeconomic status and how these differences affect transit locations. These studies also look at how gentrification shapes transportation systems and road use (Jones 2015; Habib 2014; Chaskin and Joseph 2013; Checker 2011).

While these investigations relate to the human elements of the road they are not truly ethnographic in nature. Most of these studies deal with infrastructure and how it shapes the road context. While important, it is only one side of the proverbial coin. What’s more, the
United States features a rather unique national highway system which has had and continues to have a massive impact infrastructurally, economically, and socially (Deakin 2006). The U.S. Highway system has significantly impacted patterns of residence and the prevailing economic behaviors of its citizens, as evidence by the commonality of long distance commutes (Mote and Whitestone 2011). This also has a more profound effect on the choice of transportation among people based on their residence patterns, which can impact transportation and vehicle choice (Cao 2006).

In terms of this investigation, the legal and physical environment of the road, just as much as cultural context, has an impact on the ways in which people use the road (Saelens et al. 2003). Thus, in order to better understand the ways that people use the road, we must also understand the road as a contextual environment. There are legal codes and building philosophies that create the environment we know as the road (Saelens et al. 2003). As a member of the NRC-SV HUD team, I not only looked at legal codes such as the Manual for Uniform Traffic Control Devices (MUTCD) and the California Vehicle Code (CVC); I also undertook a survey of relevant transportation literature. The MUTCD gives a more or less comprehensive guide of how roads are laid out and organized in the U.S. It includes guidelines for everything from the distance signs should be placed from the road to the proper layout of construction sites (MUTCD 2009). With these very specific and detailed rules for how roads are laid out, it should be possible for AVs to predict certain aspects about the road or read them in a codified manner.

These legal documents, in combination with the academic literature, reinforced the HUD team’s understanding that their role was to examine the more unpredictable human
aspect of road use and the human relationship to cars. We took this body of work into account in our research, and we also passed it along to other groups within NRC-SV. I would not diminish the impact of the research in the transportation studies field on the holistic understanding of the road exemplified in this paper.

2.3 Ethnography of Cars

Little ethnography of driving in a general sense has been carried out. Most of what has been written deals with niche communities or somewhat special circumstances, or a more material analysis of the car itself. To some degree, these studies paint a picture of a minority of drivers who are defined by their cars more than by their driving. By far, one of the most diverse works on the culture of cars is *Car Cultures* edited by Daniel Miller, a collection of articles on varying cultural contexts surrounding the automobile (2001). There are other anthologies of similar type such as *Car Troubles: Critical Studies of Automobility and Auto-Mobility* edited by Jim Conley and Tigar McLaren (2012). All of these works deal with isolated cases or specific subject matter, such as safety or cross-cultural perceptions of vehicles, ranging from Australian Aboriginal car culture to the intensive car modifications undertaken by taxi drivers in Ghana (Miller 2001). Other examples include Dag Balkmar’s *On Men and Cars*, which examines gendered relationships and male identity with cars in Sweden (2012). While this study gives a fantastic account of how people relate to cars, it provides little insight into the act of driving.

Some work has been done on automobility or how people move through their environment by means of automobiles or other motorized forms of transport, and the ways in
which this can impact urban design. Examples include slugging, a term for a type of informal commuting behavior in the Washington DC area, and analyses of middle class mobilities in large cities in Vietnam (Truitt 2008). In both of these cases, the analysis centers on commuting and travel behavior within the middle-class context (Bissell 2014; Mote and Whitestone 2011; Truitt 2008). There has been a large amount of non-ethnographic research in the transportation studies and urban design literature (Orvar 2015; Deutsch and Goulias 2009; Truitt 2008; Steimetz and Brownstone 2005; Zhang and Kim 2005; Saelens et al. 2003). In most cases, transportation research relies on more quantitative and sociologically informed methods. However, many of these studies give good insights into understanding traffic and the ways in which roads interact with the urban landscape (Deakin 2006; Cuena et al. 1995). If anything this body of research reveals the sheer impact that motor vehicles have on the world in which we live.

2.4 Place, Space, and Proprioception

The literature surrounding place and space illuminates how people navigate across locations. It has been nearly thirty years since the distinction between place and space, as Paul Dourish points out in his retrospective on place and space (Dourish 2006). Spatially oriented practice and place-making are now essential factors in the design of new technologies (Dourish 2006). In that same vein, there has also been a fair amount of research on place and travel behavior, including the impact of place-making on travel preferences (Lofgren 2015; Deutsch and Goulias 2009; Saelens et al. 2003). From these studies of preference in travel we come to understand that travel is a highly phenomenological and individualistic process dependent on
how an individual perceives the world around them. Preference also impacts the ways that people interact with and perceive the objects of travel and transit. This perception can also change as new technologies emerge and reshape the ways in which people perceive and understand their own travel behaviors (De Laet 1999). As technology shapes the ways that people travel, it also helps them define the ways in which they perceive themselves as travelers.

In this same vein of self-perception, there is something to be said of the way in which drivers perceive themselves in relation to their cars on the road. This is a matter of not only the situated cognition of driving, but the proprioception of the car and driver as a unit. Proprioception literature covers medical prostheses and the ways in which a human experiences their own body (Simo et al. 2014; Blank and Okamura 2010; LeMoyne et al. 2008). However, the idea of proprioception can also be applied to the way in which a driver experiences a feeling of personal space around the car. Proprioception refers to the phenomenon wherein human beings have a sense of proxemics and personal space of their own bodies. In the same way movement can be equated to the overall feeling of place, as discussed in Spinney’s discussion of cycling and kinesthetics (Spinney 2004). Travelers have a sense for the ways in which they move through a given place and how the ambiance or traffic patterns of a given locale may impact their travel. These theories all contribute insights about how we as humans navigate the landscapes and spaces we find ourselves in, which are important for understanding the ways in which the AV could be programmed to model its own behavior and sense of place on the road.
2.5 Video Ethnography and Experience Studies

Video ethnography is the cornerstone of the methods employed in this study, which is not to say ethnographic film-making, but employing video as a data collection tool in ethnography. At its core, video as a method of ethnography is a form of visual ethnography. We were lucky that in recent years more video ethnography has been conducted on travel. Fink and Taylor (2011) describe the use of visual ethnographic methods in understanding travel from the perspective of transportation research and thus provide a set of principles for conducting ethnographic work in their field. However, work on experience of place has also been conducted in public health. This work attempts to get at what it means to live in a certain place and how that sensory experience of being embedded in a place has an impact on the health of locals (Sunderland et al. 2011). These sorts of multi-sensory studies involve methods such as photo diaries or interviews with residents of a specific area as they show the interviewer around that area (Capriano 2009). Multisensory approaches to understanding place are closely connected to the methods of video ethnography, especially for films that are narrated from a first person perspective. Capturing first person experience is a tough issue because there is almost always some influence of the researcher’s presence (Lahlou 2011). As ethnographers we strive to understand our own influence on a situation while still capturing experiences of our participants in a relatively objective manner.

Fully capturing experiences on film is even more difficult with video as something is almost always missing from the frame, so to speak. A camera creates a limited framing of the world and thus cannot always be seen as a truly objective as a method. Understanding travel in this case was not just an understanding of travel by car, but also by foot. Walking as a method
for ethnographic research is not a new invention of this study. There is, of course, Ingold’s piece *Culture on the Ground*, which discusses walking in terms of human beings’ perception of the world through walking (2011). Walking has also been employed in the “go-along” method within sociology, especially in terms of understanding health in communities (Capriano 2008; Pierce and Lawhon 2015). However, one could argue that the go-along is a form of participant observation more than just an interview technique. This notion served as the basis for the idea of traveling with people on their normal routes of travel.

In addition to the study of travel using video ethnographic methods, we also engaged in the use of interaction analysis. This set of methods came naturally to this investigation a result of working with one of the pioneers in the field of interaction analysis, Dr. Brigitte Jordan. Interaction analysis in this case refers to a specific set of methods developed for understanding interactions as seen on video (Jordan 1994). This set of methodological principles served as a base for the analysis of the video collected by the HUD team both before and after my arrival. However, we found ourselves at an intersection of the go-along interview method and interaction analysis an intersection that allowed us to learn about what a place means to a participant. Inspired by Ingold’s theory, we sought an understanding how participants experience travel through their proposed mode of transport, whether that was their own feet or an automobile.
CHAPTER 3

METHODS

The investigations of the HUD team used a mixed methods approach, drawing on methods from usability, design research, ethnography, and user experience. For the most part we employed video as a method of data collection. However, we employed multiple different types of filming including first person experience studies, filmed travel-alongs, observation of street intersections and filmed prototyping sessions. In addition to collecting data by means of video recording, we also engaged in frame by frame analysis of videos and post-analysis interviews with participants. Finally, we employed a handful of other methods in side investigations which will be discussed more at length within the chapter.

The specific method utilized to investigate road user experience proved to be unique and innovative in its design. The travel-along helped create a gestalt view of road user experience. In a basic sense, it was a form of video ethnography. The travel-along consisted of accompanying road users in their daily travels as either drivers or pedestrians, all the while asking them about their experience and recording video from multiple angles. We would then review that footage with participants to gain further insights on their behaviors and thought processes. While this was our principal ethnographic method, we employed additional methods to improve our overall understanding of road use including interaction analysis. Furthermore, recording and digitizing this experience for later analysis presented many logistics problems. Overcoming these problems became one of the first goals of our project.
3.1 Tools of Analysis

One of the defining methodological features of this investigation was the use of synchronized video to analyze a situation from multiple perspectives and angles, to gain a more holistic understanding of context. This required a tool that could synchronize multimodal data. The solution was ChronoViz, a program developed by Adam Fouse at University of California San Diego (UCSD), which allows for visualization of time-based data including synchronization of video from multiple angles (Fouse 2014). With this program, we were able to anthropologically code video and audio from varying sources so that we could see a situation from more angles than our natural faculties would allow.

As a tool, ChronoViz allowed us to gain a larger picture of road user experience by utilizing multiple cameras and synchronizing the video feeds so that they could be analyzed simultaneously. This ultimately informed our methods of data collection and how we chose to use our cameras to gather data as well as how we analyzed those data. When planning the travel-alongs we specifically positioned cameras to not compensate for one another, but to obtain three unique angles of perspective on the same events. Due to the ability to easily synchronize two cameras by starting them simultaneously, the third camera could positioned in the field of view of one of the pre-synchronized cameras and synched later in ChronoViz by way of a hand signal present in both video feeds. However, there is another key technology that enabled our multi-angle approach utilizing small high quality camera equipment in the form of the GoPro and SubCam, Subjective Camera.

The SubCam is an experimental camera rig devised by Saadi Lahlou, a professor of social psychology at the London School of Economics. The Subcam (see Figure 1) consists of a pair of
glasses with a small camera attached to them this camera features a wide angle lens and rather than being angled straight forward is angled slightly downward, better simulating natural human field of view.

Figure 1. The SubCam used for conducting travel-alongs at NRC-SV. The rig itself is not in a marketable state as of yet and therefore is still considered a prototype camera setup.

The nature of the SubCam allows researchers to capture a participant’s first person perspective or at the very least close to it. The camera is powered by a small battery pack clipped to the back of the participant’s shirt collar which in the photo can be seen as the labeled black box. This battery pack provided more than sufficient power for our walk-alongs with participants, and kept the profile of the camera low. The overall weight of the camera is kept low and a built in microphone is able to capture everything the participant says without need of additional recording equipment. This made the SubCam ideal for our observations of pedestrian behavior, as it proved to be a fairly good way of capturing the gaze of participants who were navigating sidewalks and streets. One limitation of this technology is that the SubCam does not fully
capture eye movement, only head turns, thus it does not account for 100% of the field of vision that the participant has. This proved a limitation in this specific investigation as road users rely on their peripheral vision fairly extensively.

Figure 2. This shows our camera setup being used on a 2015 Nissan Sentra-SV. This vehicle was used primarily to test the capabilities of our camera and recording set ups. After testing several types of camera rigs, this setup proved to be the most efficient.

In terms of our camera setup for driving, we primarily depended on suction cup mounts for GoPro action cameras. The main thrust of this design was that the rig could be assembled easily, pose minimal intrusion and keep a low profile. All told the rig consisted of three cameras which provided three different perspectives. As you can see in Figure 2, camera one pointed toward the driver providing the view of both the driver and researcher. Camera two pointed forward and was mounted outside the vehicle. And camera three was mounted inside the vehicle on the rear window and provided a view point of the driver from behind as well as a
view out of most of the cars’ windows. The camera rigs (shown in panel 4 of Figure 2) allowed for a participant to use their own vehicle and could be set up in around five minutes including signaling to synchronize the cameras. Thus it was easy to go with our drivers from virtually any point of origin without the need for a complicated setup procedure.

These small and inconspicuous cameras also enabled the initial data collection carried out by the HUD team prior to my arrival at intersections to proceed smoothly. This was further aided by the wide angle field of view of the GoPros and high frames per second capture rate of the cameras allowing better frame by frame analysis of our intersection videos in ChronoViz. In terms of intersection video, we mounted cameras on lamp posts and stop signs on intersection corners points at each other to get a full picture of the intersection from every angle. Thanks to the size of the cameras we were able to record in a non-obvious way. However, the team did post signs informing people of the presence of cameras. In spite of this the size of the cameras helped in minimizing observer effects and allowing for our public observations to be better augmented when doing extended analysis.

3.2 Initial Data Collection and Analysis: Intersections

The initial data collection strategy developed by the HUD team prior to my arrival involved observations of traffic at key pedestrian heavy intersections. The overall purpose of this fieldwork was to observe interactions between drivers, pedestrians, cyclists, and other road users in a space where the different types of road users are forced to interact with one another. Considering that these filmed observations were meant as exploratory data to help the team
better define ways in which people interact and better inform the rest of the research. This step of the process was rapid in nature and included two major contexts relevant to the scope of NRC-SV’s test scale.

The team’s first site of observation was downtown Campbell, CA, a small area with street parking and restaurants that saw a fair amount of pedestrian traffic. The area was not overcrowded, but had enough traffic that pedestrians were always present on the sidewalk even in the middle of the day despite this still being a major pass-through for vehicle traffic. This area was mostly controlled by stop signs and the road itself was only two lanes. Thus traffic flow was restricted making the area very pedestrian friendly while still allowing the flow of vehicle traffic to proceed smoothly. The area also included “bulb-outs” or extended crosswalk landings that force cars to make slower turns and allow for better pedestrian visibility. From this site the HUD team collected roughly one hour of footage in total over the course of three different field sessions on two different days. The second site of observation was on Stanford University’s campus at a large intersection near the edge of campus. While still controlled by stop signs, this intersection involved two four lane roads and generally heavier traffic of more varied types. The Stanford data consisted of three different days and times totaling about an hour and a half of video.

The purpose of this set of field data was to begin codifying interactions on the road and observe the ways in which different modes of transportation share and use the roads. While this data collection method was designed and executed by the HUD team before I joined their research efforts, I played a significant role in the analysis of this video data, which played a key
role in guiding subsequent research. From the analysis of data from this phase we also began thinking about contexts on the road that warranted additional research.

3.3 Side Investigations

During the course of analyzing the first two data collection activities, I identified several lines of further inquiry on what it means to use the road and how we might better understand the road as a structure embedded within culture. These lines of inquiry were 1) navigation of heavy traffic, 2) the impact of road construction on travel behavior, and 3) the nature, placement and regulation of traffic signals. Each line generated small scale side projects which I undertook to help us paint a more comprehensive picture of the road. While none of these investigations were rigorous enough to stand on their own, each one contributed a valuable facet to the team’s continued research. The primary thrust of these investigations was to take into consideration how an AV might need to recognize various road contexts and signals. A secondary goal was to begin to theorize how an AV may perceive the various road users it may come into contact with while traveling on roads with people. These investigations consisted mostly of desk research into the legal and historical precedents for the aforementioned road contexts. In addition to the desk research I recorded approximately three hours of additional video during investigations of construction sites and various road contexts not seen in the travel along data.

For our understanding of construction sites and heavy traffic, I decided to employ participant observation augmented by video recording. I rigged up my own vehicle with the
GoPro set up used in our travel-alongs, and took drives through some road contexts we had not
gotten in prior investigations. I used California’s department of transportation database to learn
where road construction was happening and impacting traffic. I then set up the camera rig in
my car and drove to those sites to see the different ways construction sites were laid out and
how construction crews managed traffic in those areas.

My other side investigation into traffic signals and road laws involved desk research and
comparative methods. Chief among these methods was a comprehensive review of legal
documents including both federal and state laws that apply to roads and road users. It was
enlightening to have these points of reference as context for comparison with the data we were
collecting. In theory, an AV should be designed to follow the law exactly. However, as is
somewhat self-evident, human beings do not follow the laws to the letter and there is an
element of cultural variation in driving style. Thus in understanding how to create an AV that
can be integrated into the human system of road use we need to understand both the
standards by which the AV will operate and the standards under which human road users
operate.

3.4 Travel-Along

3.4.1 Participant Selection

Participant selection for this study proved to be a learning experience. When initially
recruiting we pulled from the Nissan Bay Area Leaf owners group. However, the first two
participants pulled from this organization and its affiliates were older white males who could be
classified as early adopters and thus produced homogenous results. In the anthropological fashion of desiring a diverse sample, we decided to expand our recruitment to include the social networks of the NRC-SV employees. All told, our sample for travel-alongs included six participants ranging in age from mid-twenties to late sixties, with three men and three women. Our participants varied significantly in occupation, ranging from students, to tech employees, to doctors. All of our participants were white, though some had significant international travel experience in countries such as Germany, Ukraine, and South Korea. All participants also had some amount of travel experience within the United States. Travel-alongs were divided equally between three drivers and three pedestrians.

For our selection of participants, we felt that those recruited presented a good cross-section of possible end user groups who would be potential early customers of AVs. Our testing locations in and around the Silicon Valley and Bay Areas meant that our participants would be in the first wave of people to experience AVs on a daily basis upon release. Our participant demographics also addressed key groups of individuals who are likely to be early adopters or users of AVs such as young technology sector professionals or those with the economic means to purchase new cars every few years. Among our participants we also had people who favored public transportation usage, which is another proposed model of AV release and usage. Our participants had a varying level of technological literacy, which was advantageous since the eventual target market of AVs is the general consumer market. Table 1 enumerates the basic demographic information of our participants as well as the type of trip we accompanied them on. Each trip we took with participants was selected by the participant to demonstrate a regular activity they would undertake in their day-to-day travels.
Table 1 Participants

<table>
<thead>
<tr>
<th>PARTICIPANT ALIAS</th>
<th>WALK/DRIVE</th>
<th>AGE</th>
<th>GENDER</th>
<th>OCCUPATION</th>
<th>PURPOSE OF TRIP</th>
</tr>
</thead>
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<tr>
<td>PETER</td>
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<td>Male</td>
<td>Psychiatrist</td>
<td>Running daily errands</td>
</tr>
<tr>
<td>MARK</td>
<td>Drive</td>
<td>55</td>
<td>Male</td>
<td>Retired</td>
<td>Driving to an event</td>
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<tr>
<td>COURTNEY</td>
<td>Drive</td>
<td>25</td>
<td>Female</td>
<td>Student</td>
<td>Commute to school</td>
</tr>
<tr>
<td>DENNIS</td>
<td>Walk</td>
<td>28</td>
<td>Male</td>
<td>Tech professional</td>
<td>Commute to work</td>
</tr>
<tr>
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<td>Walk</td>
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<td>Female</td>
<td>Court Clerk</td>
<td>Walk through downtown</td>
</tr>
<tr>
<td>TANYA</td>
<td>Walk</td>
<td>43</td>
<td>Female</td>
<td>Sales Rep</td>
<td>Walking the dog</td>
</tr>
</tbody>
</table>

3.4.2 The Travel-Along Method

While I would not refer to the travel-along as the principal method of this investigation, it was certainly the most ethnographic in nature. While directly based on the methodology utilized in the Design Anthropology Course taught by Dr. Wasson, there is also precedent for this methodology in the world of public health as well as in design research. This type of “go-along” method has primarily been employed in studies which seek to identify the impact of place on public health (Capriano 2008). The basics of this method are quite simple: an ethnographer goes with a participant as they travel through their environment, asking questions to get a better sense for how a participant experiences their environment as a place. In our case we were also concerned with perceptions and experiences of road use. In a more direct sense this method as well as the paradigm employed in analyzing the data come from a lineage of work from Brigitte Jordan and Austin Henderson’s work on interaction analysis (Jordan and Henderson 1995).
To better understand the experience of driving among our participants, we expanded
the original method used in the Social Life of the Car Project. In that project, our travel-aways
consisted of a pre-interview and a drive along with the primary aim being to gain an
understanding of how people relate to their cars as social objects. The methods used in the
Social Life of the Car also included a post-driving interview that examined some of what was
observed, but did not include replaying video data with the majority of participants. In the HUD
team’s investigation, we were more interested in the experience of travel as a road user, so we
expanded the study participants to include both drivers and pedestrians. As stated previously,
we employed a multi-angle approach for recording the travel-alongs themselves. We also
amended the post-interview session, adding to it a review of analyzed footage from the travel-
along in the style of interaction analysis (Jordan and Henderson 1995). It is important to note
that the roots of our methods, both in this project and in the Social Life of the Car project, were
located firmly in traditions of interaction analysis. The two anthropologists at NRC-SV, Brigitte
Jordan and Melissa Cefkin, have a history of developing and utilizing interaction analysis in their
work (Cefkin and Jordan 1994). Our methods can be broken down to three distinct parts which
will be reviewed in sequence: the pre-travel interview, travel-along, and post-travel interview.

3.4.3 The Pre-Travel Interview

The pre-travel interview consisted of gathering the personal history of our participant,
including basic demographic data. It was during this step that we also asked about their history
as a road user, as both a driver and a pedestrian. These questions included when and where
they learned to drive, their level of familiarity with the local area as well as discussions of other
locations or contexts they had experience traveling in such as other states or countries. We then asked them to explain to us the route or trip we would be joining them on in their own words. We felt that by letting the participant select the route of travel we would be able to observe their behavior in an area that they were familiar with, and thus get a better idea of their day to day road use. For the most part, interviews lasted between 45 minutes and an hour and were audio recorded. To accommodate the speed of work, no full transcriptions were made of these interviews; however, full analysis notes were compiled by all members of the HUD team.

3.4.4 The Travel-Along

The travel-along itself consisted of taking trips with participants, as they went about their day to day tasks. We video recorded the experiences, and informally interviewed participants about events as they transpired and engaged in general conversation to further build rapport. Of all the steps in the process this was by far the most highly varied between participants; however, typically this phase took between forty five minutes and an hour with the longest being an hour car ride and the shortest being a 16 minute drive.

After collecting the footage we often had only a 24 hour window within which to export and synchronize the footage. Due to limited processing power of the GoPro camera this was not a simple movement of data from a camera to a computer. When capturing in high frame rate and high definition the GoPro divides footage into roughly twenty minute segments which then have to be stitched back together. Thus for quick turnaround it would be necessary to
import the twenty minute segments in a non-compressed format into editing software, stitch them back together then re-render them in a smaller, more convenient MP4 format. For the sake of redundancy the travel-alongs were also audio recorded in case one of the internal cameras failed in such case the audio would be synchronized with the external video. The importance of the quick turnaround with the video synchronization was primarily linked to our twenty four hour window in which to perform the post interview. This was primarily to ensure that the memory of the events recorded were fresh in the minds of participants.

3.4.5 The Post-travel Interview

This post-travel interview session was one of the most useful components of the travel-along methodology. In this session we reviewed the footage of the drive or walk with participants, asking them to narrate the experience and asking questions about behaviors that the research team found relevant. The post-travel interviews were audio recorded. This sort of collective analysis allowed us to gain greater insight into the reasoning of our participants when it came to decisions they made on the road. It also allowed us the opportunity to further explore questions that may have arisen while viewing the video for the first time. Depending on how much participants had to add about their experience, these sessions tended to last anywhere from 30 minutes to an hour and a half.

During this post-travel interview we also engaged with our participants regarding general questions about AVs and their attitudes toward the possibility of sharing the road with AVs and using AVs themselves. This final interview segment, though improvised at first proved
to be a valuable asset in determining how our participants viewed AVs as potential entities that would share the road with them. Following the post-travel interview, field notes were compiled collaboratively by the HUD team over the course of the week and augmented by discussions in IALs.

3.4.6 Rapid Prototyping

One of the other methods employed in this investigation was more focused on direct design ideas than on better understanding the human elements in a more subtle way. In particular, we were looking at how humans might interact with an AV. In order to facilitate this, the HUD team worked to create a prototype of an external human machine interaction (HMI) system designed to show the intention of the AV. The prototype was constructed and tested based on observations from the intersection observations. This involved a distinctive research-led approach to developing prototype HMI concepts based on data analyzed in the team’s weekly interaction analysis labs (IALs).

The prototype itself consisted of a remote controlled toy car with a panel of LEDs attached to the front. The panel was controlled via a small remote that toggled the color or intensity of the LEDs by means of an Arduino computer. The prototype was to serve as a proof of concept for possible implementations of external HMI systems that could be implemented to help AVs interact on the road based on observed behaviors of both drivers and other road users.
In terms of our rapid prototype, participants were recruited from the office. The prototype, as stated before, was more or less a proof of concept for one possible implementation of an external HMI system. For this purpose the prototype was small and tested in the relatively controlled environment of the NRC-SV office.

The aim of this specific prototype was to examine interactions between pedestrians and AVs, thus we designed testing scenarios to fit these interactions. The testing itself was divided into two phases. Phase one was a controlled usability test with planned scenarios and interactions. Phase two was a more naturalistic test; the prototype was set up in a common area of the office where it would cross paths with people on their normal routes between spaces in the office. In both cases we attempted to recreate the scenario of a crosswalk and set up a camera for video recording the interactions as they happened.

In the controlled scenarios, we used masking tape on the floor of the room to create a road and a crosswalk. We then prompted participants to interact with the vehicle in different scenarios, such as waiting for the car to come to a complete stop before crossing, lingering and then crossing, or waiting for the car to pass before crossing. In addition to this we also had participants experiment with jaywalking and crossing not at the crosswalk. These tasks were repeated with several different implementations to determine which implementation would be the most learnable, usable, and intuitive for the casual observer. The implementations differed based on what kind of signal the LED panel was sending to our participants. Various signals included solid colored lights, flashing lights, and other more complex signals.
In phase two of the test, we used masking tape to create a mock crosswalk in between two main areas of the office where we knew people frequently walked in their day to day tasks. We then intentionally operated the remote controlled toy car so that it would cross paths with people as they navigated through the office. In this instance we used the same lighting implementation for the entire testing period. This testing scenario was designed to put participants in a more natural setting of having a location they are trying to get to rather than just performing a task scenario. This was also an opportunity to solicit design feedback from coworkers and get a better understanding of how the external HMI might be interpreted by users.

The goal of the prototype design was to simulate the ability of an AV to show other road users the intent of the car when it was starting and stopping. This signaling emulates the signaling methods of drivers to pedestrians by means of eye contact or hand gestures. We hypothesized that an external HMI system could emulate those human forms of communication. An important aspect of this design was not to replace or copy human interactions, but to create a way for the AV to communicate the same message in a way that is conducive for human understanding. At the same time it was important to still make use of the unique characteristics of the AV.

3.4.7 Analysis

Analysis included both collaborative sessions and extensive coding. Collaboration with my colleagues at NRC-SV mostly took place through Interaction Analysis Labs (IALs), a term
coined by Henderson and Jordan (1994). IALs consisted of weekly meetings where the HUD team would collaboratively analyze video data from every step of our process. These meetings were an ongoing part of our work and while generating excellent findings and allowing us to iteratively refine our ideas, they also generated ideas for further study and subject matter for side investigations. Paired with this collaborative approach also came ideation sessions and communication with other departments to understand how our work might apply to other projects being conducted at NRC-SV. These meetings helped us to keep our research questions in the back of our minds at all times. This meant that analysis concepts or findings emerged from workplace conversations and from thinking of events in our own travel lives.

In addition, we did extensive coding of the travel-along data in ChronoViz, as well as compiling field notes on the interviews and on video taken at other points during the investigation. From these field notes we compiled a basic list of findings that we could then corroborate with clips from our video. While the original intention of the investigation was to examine interactions among road users, our findings ended up revealing much more about the nature of road use as a whole than simply how people interact with each other on the road. This was due in part to the combined analysis of all of the various types of data we had collected through our different methods. Arguably this broad and sweeping approach was one of the most unique aspects of this project. Ethnographic methods, mixed with usability testing of a rapid prototype, design ideation, and desk research related to the field gave us a multifaceted viewpoint that no single one of those methods could have produced by itself.
CHAPTER 4

FINDINGS AND DISCUSSION OF THEMES

4.1 A Brief Note on the Nature of this Section

The findings of the HUD team to which I contributed were numerous and applied to several different projects. I am still bound by a Non-Disclosure Agreement not to reveal findings for some of these projects. In this section, I present an analysis that I finalized after completing the internship, although it builds on the collaborative analysis of the whole HUD team. It is centered on the concept of “the AV in the world.” This concept had emerged as the primary framework for my analysis by the time I left NRC-SV. The phrase, “the AV in the world,” refers to the idea that the AV will need to exist both as a designed consumer product and as a member of the human road system, not just in the US or on the roads of California, but eventually in the entire world. The AV will need to coexist with other road users and thus it needs to be able to survive in that system and be understood by other road users. However, this is not to say that an AV must mimic human interactions, but must be a learnable and teachable entity within the greater context of the road. This chapter will mainly focus on the problems the AV may face in the world, how it might navigate them, and how it might be integrated into the system of the road composed of not only the culture of the road, but also its legal parameters and physical structures.

The findings discussed here and their implications were included in the final presentation to the entire NRC-SV office, but due to NDA not all of the specific design
suggestions can be included here. Thus the focus of this section will be on the broad implications of the work, rather than the specific design suggestions geared toward Nissan.

4.2 Personal Space on the Road

One of the most important things revealed in our interviews and travel-alongs was the idea that people have a concept of the places in which they live; this is more than just location based map knowledge, but knowledge of the workings of the places they travel. This kind of knowledge includes everything from when roads are busy to which intersections they can cross with ease when walking. With this also comes a sense for the road gained when driving, such as the ability to discern when traffic is going to get heavier and an awareness of one’s surroundings allowing quick changes in navigation.

From our travel-alongs we have some examples of this sense of place people have about the road. During a drive with our participant Peter he noted that traffic was getting a bit too heavy for his liking. Rather than taking the road we were on, he diverted course and took side streets to our destination instead. When asked about this behavior Peter informed us that he would rather take a longer route and keep moving than sit in traffic. What we can gather from this is that the preferences of drivers for certain behaviors and states impact their driving habits. These preferences ultimately affect the ways that they navigate and the awareness that they have of the road. Much more than this awareness of the road is the awareness of the car itself and the sense of proxemics that people have with their cars similar to their sense of proxemics with their own bodies, as we saw in our observations of intersections.
We found distinctive patterns in how road users managed their proximity to each other. For instance, cars waiting at intersections for pedestrians to cross in front of them typically started moving before the pedestrian had completely exited the crosswalk. In most cases, drivers moved forward after the pedestrian had taken two or three steps past their vehicle. We also observed pedestrians who had yielded to vehicles begin walking after the vehicle had crossed their path, but not fully passed them. Often times in this situation pedestrians would adjust their own course to move more toward the rear of a vehicle as it passed in order to maintain their own speed. The same pattern was again observed in cars speeding up and coming to a rolling stop before continuing in order to make it through an intersection before a pedestrian reached the crosswalk.

From this pattern of behavior I developed the concept of a “zone of action” surrounding vehicles and other entities that road users use to judge their distance keeping and interactions. There is a sense of personal space around the vehicle that has to do not only with space around the car, but the space that a car or other entity could potentially occupy in the near future. The zone of action depends somewhat on the direction of travel of a given entity, for instance a car moving forward after the pedestrian had passed two steps clear of its path. The concept of a zone of action was further supported by our interviews, as three of our participants indicated distance keeping as an important part of their driving and interaction, and all of our driving participants exhibited the crosswalk passing behavior.

The zone of action concept refers to the sense of motion that human road users demonstrate in relation to how they predict the actions of others. For instance judging that a vehicle moving forward at a given speed will continue to do so and roughly cover a predictable
distance. However each type of road user possesses a different zone of action based on speed and direction of travel. As exhibited in Figure 3, cars demonstrate long and forward heavy zones of action because of the nature of the car as a road user. Meanwhile pedestrians tend to have a more circular zone of action because of their ability to rapidly change the direction of their travel. Cyclists on the other hand, while having a narrower zone of action were perceived as unpredictable by all participants thus their zone tapers out wider the further from the cycle one tries to predict. The hybrid road and sidewalk use of cyclists makes them a more unpredictable element when it comes to interaction.

*Figure 3. A visualization of the zone of action for three types of road user from left to right: car, pedestrian, and cyclist. This image is not to scale and shows only proposed Zones of Action as the concept has yet to be quantified.*
Decision making and path planning typically takes into account if two zones of action or their paths will overlap or collide in the near future. Such a prediction causes a need for negotiation between road users, such as signaling or yielding. The ways in which these zones interact, or would potentially interact, help people predict how others will move so that they can act accordingly. By predicting where agents on the road are most likely to be and by picking up on social and semantic cues from other road users, we can navigate in an efficient and safe way even through heavy traffic. The idea of prediction based on likely future location drives current industry thinking on how to build path prediction in AVs. Because this type of behavior is clearly observable, it is significant to understanding how these interactions happen. AVs rely on path prediction algorithms to do roughly the same thing that humans do on a day to day basis. The algorithms need to be designed for safety in a way that incorporates both human ideas of safety and machine precision.

As explored above in the discussion of zones of action, humans do more than just predict the possible paths of a vehicle or road agent; they also pick up communications with other road users and have a sense for the flow of traffic that is heavily nuanced. This results in a mostly accurate set of predictive mechanisms for road use and safety that are difficult to emulate in AVs. The current paradigms of AV path prediction rely on the use of LIDAR paired with cameras and advanced prediction software, allowing the AV to predict paths and “see” zones of action. Thus the AV will be able to judge zones of action in a way that will theoretically surpass human ability in terms of precision. This means that an AV could follow more closely on the road and still have reaction time to engage its brakes should something happen. This level of precision makes the AV an odd addition to the road user environment. The basic idea of “just
because it can, does not mean it should” applies here. When thinking of how precisely an AV could predict and therefore act in relation to predictive pathing we have several possible outcomes, such as closer following distance or closer pedestrian proximity. An understanding of the ways in which human drivers perceive the zone of action of various road users becomes hugely important for the design for pathing prediction. The ultimate goal in this type of pathing and interaction design is for the AV to behave in a socially acceptable way. As revealed in our travel-alongs, the perception of what constitutes appropriate distance keeping is culturally situated and can vary immensely. For instance, one participant from Southern California felt more at ease with cars that followed her closely on the highway than around those that kept a larger following distance. This was due to her learning to drive in Southern California’s bumper to bumper traffic. This was contrasted by a participant who had learned to drive in Germany and referenced the extremely orderly and incremental follow distances dependent upon speed who felt that tailgating was a bad habit of American drivers.

All of these factors have to do with the AV having a sense of space and proxemics, with the car’s sense of place in regards to itself and other acting objects. But so far the model for AV proxemics presented above fails to take into account environmental factors and contexts of operation. The ways in which we behave on the road are not only dictated culturally and by the actions of other road users, but by the places we travel.
4.3 What it Means to be Local

In order for AVs to be user-friendly and user centered, they must account for local variations not only in their own driving practices, but in the way that they interpret and predict the actions of other cars. How then do we transfer these kinds of human knowledge to an AV? Developers expect that AVs will be networked with various information outlets, social media networks, and civic databases. An AV could pick up some local knowledge through such connections. But the question really is, how local can an AV’s knowledge base become? Learning algorithms can take into account a whole lot of information, but can they replicate the complexity of a long-term resident’s local knowledge?

Human drivers not only have in-depth knowledge of the terrain they navigate, they are also enculturated into local driving practices. The cultural context in which someone learned to drive shapes their driving style. Everything from the way in which a driver approaches a stop sign to the way in which someone merges on the highway are conditioned by the area where they learn how to drive or places where they have driven. Fortunately, we had quite the diverse group of driving contexts represented in this investigation. Contexts our participants had learned to navigate included: Southern California, the Bay Area, Germany, Vancouver, Ukraine, and New York. Each of these contexts offered a remarkably different set of standards and practices that shaped the driving behaviors of our participants. We needed to consider how this diversity of driving styles might impact the interactions of AVs in the world.

One example of the challenges AVs would face is the discrepancies between official driving rules and the localized and socially constructed practices of drivers. I conducted a comparison between the California Vehicle Code (CVC) and California Driver Handbook, and the
actual practices we observed on the road. I found a myriad of small discrepancies between the letter of the law and how people actually behave. An example was the local practice commonly known as a “California stop” or a rolling stop. This refers to when a car does not come to a complete stop at a stop sign and instead rolls through that stop sign by slowing down to a crawl until they determine it is safe to continue. To some this may sound dangerous, in other parts of the country such an action may be grounds for a traffic ticket; however, in California this is common practice. What is interesting is that this type of stop, according to the letter of the law, is illegal yet it is still common practice and police take no action against it. The problem arises when you introduce an AV that, due to legal restrictions, must follow the law exactly. In such a situation, the AV will not behave in a way that is natural or socially acceptable. By following the law exactly, the AV will be more likely to be a disruptive force on the road than one that can be more easily integrated.

While this technically illegal practice may be an extreme example, our interviews revealed more minor differences that could still cause concern, such as merging onto a highway. Highways are considered one of the first places AVs can be successful, as long, mostly straight roads are easy to navigate, and for the most part require less intensive detection of other road users such as pedestrians or cyclists. However, the question remains as to how an AV will merge on the highway. In the Bay Area it is common to see what is colloquially known as a “zipper merge”. This more or less means that in the dense traffic of the area cars entering and exiting the highway function in much the same way as a zipper with cars interacting on a one to one basis. However, one of our participants who learned to drive in the heavy traffic of Orange County, California, felt this method of merging was too passive because she had grown more
used to an aggressive merging style common on the mega highways of southern California. This notion brings up the question of whether the behaviors coded into an AV will incorporate not only the traffic laws of the relevant country, but also local, culturally inflected driving practices. For at least some period of time, AVs will need to coexist with human drivers on the road. That period of coexistence means we will have to integrate human practice and knowledge with the technology of AV. This kind of integration already happens in our daily travel lives, as one of our participants, Mark, explained:

“[I’ll input] into the Nissan then it’ll tell me which way it thinks is fastest or best, then I’ll add knowledge, like my own knowledge of the roads, and I’ll add what Google maps says... I’ve lived here my whole life and if it [the GPS] says I should take El Camino, but I know Fremont Ave is a better street I will take Fremont despite what it says. Sometimes it’s just a more pleasant road and sometimes I know it is a better choice.”

This quote from Mark demonstrates how he integrated his own local knowledge of the area with the technology available to him in his car. More importantly this quote demonstrates the summation of upwards of 40 years of driving experience in the Bay Area. This level of local experience shapes the way Mark drives on a day to day basis and is impacted not only by knowing routes, but also knowing events that happen in his area. As someone lives in an area for a longer amount of time, they will grow more familiar with various factors that impact traffic. Examples include schools that generate traffic at certain times, places that tourists go, and local events that may lead to increased traffic. These kinds of knowledge are embedded
into our society and into our road culture, they are part of what makes the human road system work.

As the above quote illustrates, drivers creatively choose their routes, and the potential for losing control over their routes is one of the things participants expressed worries about. This led us to the idea of allowing users to “teach” their vehicles or allowing the car to learn from its surroundings. This is not a new idea by any stretch of the imagination. But the idea that to some degree the AV may need to pick up some bad habits in addition to good ones in order to properly integrate into the human road system is one that requires more research on the nuance of local driving and navigation styles and driving styles.

Being a local not only pertains to driving in a style that fits with local customs, but also to navigating through traffic. Several participants complained about GPS directions taking odd paths. This was best expressed by one of our participants, Peter, who frequently deviated from GPS directions to take shortcuts. Peter reported that he knows the area he’s in well enough that even if he is using his GPS to get somewhere, if he knows a shortcut he will take it to avoid getting stuck in traffic. Peter also expressed frustration at using a GPS for long trips as he felt it often led him to roads that he felt did not always make sense. This notion of the GPS being illogical also goes back to the quote at the opening of this section. Mark used a synthesis of information and experience to navigate rather than relying wholly on a GPS. His driving habits not only reflected local knowledge, but a knowledge of how things change.

Drivers’ knowledge of changes on the roads was best exemplified by our participant, Janet, who talked extensively about how things in her town had changed in recent years with
an influx of tech sector workers to Redwood City. Janet was able to cite specific roads and routes that she now avoids in her day to day travels due to the increased traffic or shifts in traffic patterns. While Janet was one of our walk-along participants, she gave us extensive details on the traffic patterns of the area we walked through. She reflected on why the changes had happened and how the influx of people and jobs had changed more than just traffic, but the local character of Redwood City. Janet also commented on the diversity of locales in the Bay Area:

“Living on this peninsula, everybody drives, you almost feel like you live in all these towns... you’re always traveling through a lot of different towns... and each one has its own character.”

Janet had learned what she referred to as the “character” of these places by living in them, in this way she has developed her own ways and routes of navigating and getting around. Her knowledge included not only local character, but also local events and scheduling. For instance Janet pointed out that she avoided a certain street in the evenings after the construction of a new movie theater due to increased traffic or changing her routes in accordance with commuting hours to avoid heavy traffic. This kind of intuitive navigation poses another possible issue for the design of AVs. Creating a sense of local knowledge requires a lot of resources, but it can be aided by user input.

Just as humans must learn how to drive “correctly” upon moving to a new city, or country, so also can we teach AVs to follow local practices. While not all of these lessons may be bad habits or legally gray actions, such as the rolling stop, there will be just as much
opportunity to teach AVs directly and also to have them learn from their environment. There is also great potential for AVs to share knowledge with each other through cloud computing, further accelerating the learning process. If the basics of local practices can be shared through cloud computing between vehicles, it may also lead to a further emphasis on user customization of vehicle experience. While the notion of more customization through cloud-computing may seem counter-intuitive at first, if we consider that the basics of local practice could be shared, it would allow for greater nuanced customization from individuals for their specific vehicle. These were some of the implications of the idea of a vehicle becoming local to a given area, although at this point, it is too early in the development and integration of AVs to make concrete predictions.

4.4 Robots Navigating a Human World

Human machine interaction and communication is pivotal to a properly functioning system. Effective communication between human users and computer-based systems is an important aspect of any design. With AV design effective communication is crucial; if communication breaks down between humans and AVs, lives could be at risk. Thus, when discussing implications of the AV in the world, one of the key themes to discuss is the ways that AVs and humans will communicate.

In the most basic sense, an AV is a robotic vehicle with some degree of artificial intelligence. When we consider the AV from this angle we must ask some of the classic questions of what it means for a robot to navigate the human world. There are some examples
of robots in this context such as hitchBOT, the hitchhiking robot, which in the summer of 2014 hitchhiked across Canada with the help of other travelers (hitchbot.me). HitchBOT was designed to interact with people by means of LED displays on its head which could display both text messages and simulated facial expressions. This allowed hitchBOT to ask passersby for rides to different cities, where it would subsequently be left on the side of the road to hail another traveler using one of its robotic arms. HitchBOT is not the first example of a sort of quasi-android, a robot designed to imitate or interact in a human way. The idea of making the AV personable in such a way that people might want to help the AV by being courteous is often proposed as a solution to the human AV interaction problem.

On the surface this may seem like a workable solution to human on AV interaction, but there are examples of humans interacting with robots in a negative way. Chief among these is hitchBOT’s journey through the USA, which contrasted sadly with its positive reception in Canada. In the summer of 2015, hitchBOT began its journey in Salem, Massachusetts and only made it as far as Pittsburgh before being dismantled and left on the side of the road. Despite its success in Canada, in a different cultural context hitchBOT’s personable design did not result in positive interactions. In a similar way, there is evidence of people purposefully impeding robotic systems such as robotic museum docents in the northeastern US (Stubbs et al. 2005). With these cases in mind and with the conclusion of hitchBOT’s journey in the US occurring during my time at Nissan, we analyzed some of our prototyping activities in terms of this idea of a personified machine. During prototyping, study participants ascribed a personality to prototype based on its “body language” and assigned it intent based upon that personality. They would refer to the car as “aggressive” or “thinking about going.” In some cases they would even
ascribe actions to the way in which the lights on the prototype flashed, saying that the car was “waving them through” the simulated intersection. The anthropomorphizing of the prototype raised interesting questions about the ways in which the AV will be a personified entity in the world.

Through our work with the interaction prototype, we discovered that in most cases people have a mental framework about the behavior of cars. Because people do not always see the driver of a vehicle when they interact with it, they typically assign both gender and agency to the car itself. This practice brings into focus a key component of AV interaction, a way to differentiate an AV from other cars on the road. This need for differentiation is something reflected at both the prototype stage of our investigation as well as in our travel-alongs. Participants expressed a desire to know when a car is being autonomously driven because it changes the way that people will view the car and interact with it. Often times during the prototyping experiments, our participants would note that they interacted differently with the prototype than they would with a real car because the prototype was “autonomous.” They would then describe the differences. Chief among these differences was the idea of eye contact or lack thereof in the case of the prototype. Participants articulated that because there was no driver to make eye contact with, they judged the intent of the vehicle by the body language of the car paired with the interactive lighting display.

This idea of eye contact and of interaction as an important part of navigation frames many of our travel behaviors. We depend on our ability to communicate to one another. When communication breaks down or cannot be performed, people rely on assumptions about the affordances of vehicles and tend to ascribe some sort of intent to the driver of that vehicle.
because they can in some way relate to the driver. This is not the case when dealing with an AV; there is an unknown element because the entity in control of the vehicle is not human. For this reason there is a delicate balance to be struck in design of AVs and the way that they interact with other road users in such a way so as not to directly mimic human interaction. In essence this means that an AV must communicate in a way that is particular to AVs, but learnable and intuitive to road users. When designing the ways that AVs will interact on the road we have to take into account that they will need to exist in the natural world and people will need to learn how to interact with these new road users. We have to take into account that there is no way for a car manufacturer to distribute a manual of signs and signals to every single person the car will interact with. Thus in our designs of external interaction systems we must strive for systems of signaling that are simple, learnable, and complement the body language of the car itself.

The body language of the car is an important aspect of communication on the road, so much so that regardless of the finite ability of an AV to follow closer or stop shorter than a human, it may not be wise for an AV to do so because it may influence the way that other road users perceive the vehicle and its intentions. A short stop or close follow distance may be perceived by other drivers as overly aggressive or dangerous, even if these actions are “safe” for an AV. There are also actions that communicate in a nonverbal way, such as removing one’s hands from the steering wheel when letting a pedestrian cross at a crosswalk, a behavior exhibited by our participant, Mark, during our drive. In the post-interview while reviewing this footage, Mark commented that he was unaware that he removed his hands from the wheel. With the sheer number of ways that people communicate from their cars, it is almost a wonder that other people can in most cases understand the intended message. Communication is one
of the major issues to consider when designing how these robotic cars will navigate a human world.

4.5 Predictable Roads and Human Chaos

Roads are highly ordered and predictable structures in the US. The people on them however, are a varied tapestry of behaviors, vehicle types, and driving practices. Thus an AV cannot exist in a vacuum as a robotic entity designed to navigate just the road. Through our investigations into transport literature, legal codes, and the Manual of Uniform Traffic Control Devices (MUTCD), we gained an understanding that the lion’s share of road contexts, at least those in the US, can be predicted and modeled in such a way as to be easily understood. Roads are built to certain codes and standards, and with mapping technology. It is fairly easy for an AV to predict the road itself. Even in cases of construction or road work, we found that departments of transportation are required to follow certain rules and report locations and times of road work. In many cases, this information is sent to databases that can be utilized by app developers. For this reason the AV can know when there is construction due to its connected nature. It can also, to some degree, predict the layout of the construction site. This is because the MUTCD dictates the layout of construction zones including flag man placement. However, what makes this situation difficult for an AV is the dense, often chaotic human road user traffic surrounding construction zones.

During the course of this investigation, I conducted several small documented drive throughs of construction zones to better get a sense of the road user interactions. What I found
on these investigations is that construction site congestion often slows traffic. It is important to note that these investigations were preliminary and served the purpose of determining if construction zones would pose significant challenges to the AV. This small investigation suggests that while the AV may be able to predict road construction, it cannot always predict the way other road users will behave in those contexts. I have recommended further investigations on the subject of specific interaction contexts on the road.

4.6 Conclusions

The HUD team’s investigation into the potential nature of the AV as a road user proved quite fruitful as groundwork for future studies. While we had originally set out to investigate road user interaction patterns, what we unveiled gave us insight into viewing the road and its users as a system which was composed of both infrastructure, and the meanings people impose upon that infrastructure. Driving, as was known prior to this investigation, is a social act, but much more than this, it is also regionally and locally situated within cultures. This thought poses one of the most interesting questions for AV research and design: how will AVs actually behave on the road and will those behaviors be different in different parts of the world? This behavior could be solely the product of legal guidelines the AV will follow, but AVs will navigate much more effectively if they take into account cultural driving practices.

Considering that this study revealed large discrepancies in driving styles even between regions of the US, culturally situated driving styles are one of the main areas for future examination on a more focused basis. Being able to codify information about culturally
inflected driving styles throughout the world would allow for integration of that information
into the AV’s systems, facilitating the integration of the AV into society. Integration of these
behavior patterns can also lead to phasing out risky driving behaviors in the long run.

The period in which AVs and human drivers share the road is the context in which the
theme of the AV in the world is crucial, the notion that the AV will need to coexist with human
practices of road use. This means that the AV cannot be designed in a vacuum or designed to
perform only in a controlled environment with other AVs as its only other interactions. AVs
must be designed to mesh well with the human road system as it exists, and their design must
account for the variability in road user types and behaviors. The central thrust of this thesis
project has been to demonstrate such issues and examine the ways in which the AV might be
integrated socially into the world.

There is still much work to be done on the subject of the AV in the world. As its
development continues to move forward, much of that work will be done by social scientists
alongside the engineers and designers who will be bringing AVs to market. As was
demonstrated by this quasi-exploratory study, there are many areas of investigation to consider
in designing AVs because travel will continue to be a culturally embedded behavior even after
AVs take to the road. There is no doubt that societies will adapt to the presence of AVs and
create their own codes and ways of understanding and communicating with AVs. As designers
and anthropologists all we can do is try to create ways for the AV to facilitate that
communication in a way that is unique to AVs and makes them easily distinguishable on the
road as an independent agent and road user.
The processes of undertaking this study, this internship, and the execution of this project were a veritable whirlwind. From the time I was offered the internship position to the completion of the required thesis proposal, the nature of the project itself was fluid. Next thing I knew, I had an apartment in South San Jose and was on my way to my first day of work at NRC-SV. In my first few weeks, the project itself began to take shape, mostly due to the need to state exactly what we planned on doing in the IRB application. I was one of the first interns to arrive at NRC-SV because my summer break started earlier than the rest of the interns, and due to my academic scheduling. I was also the first to leave as my summer break ended earlier. Almost all of the other interns were from Stanford and did not show up until a month into my internship. Thus, I was absorbed in my work for lack of companionship. The other members of my team had meetings or other responsibilities to attend to on a daily basis. I spent that solo time trying to innovate and to connect the dots of what makes up the road as a system. I read much of the literature contained in the bibliography of this text during those times as well as conducting several of the side investigations discussed in the methods section. This wealth of information and knowledge became a framework for further discussions with my colleagues about the work we were doing.

I lived, breathed, and drove in one of the most congested traffic areas in the country. Between my hour to hour and a half commute each way to work and trying to devise camera rigging for cars, I did a lot of driving both for research and for fun in the Bay Area. My driving experiences informed my contributions to the HUD team’s research framework. For me, living
in California even for just a few months meant that in one year I had moved from Florida to Texas, then from Texas to California. I traveled from sea to shining sea through three distinct climates, cultures, and driving contexts. My own travel history not only informed my perspective on mobility, but on driving. Like most anthropologists working with what could be considered such a mundane task as driving, I had become hypersensitive to the contexts of navigating the road. I brought this experience with me and it created a way of looking at things. It made it easier to notice the differences in traveling practices, not to mention giving me something to do during my long commutes back from Nissan’s Sunnyvale office to my San Jose apartment.

By the time we started actively recruiting participants for our travel-alongs, we had already begun prototyping and had collected and observed upwards of 50 total hours of video. Due to scheduling to drive with people during the work day, our travel-alongs were scheduled sporadically so the process often went in fits and starts. Intense analysis followed the data collection of the travel-along, and then we would return to side projects, prototyping, and extended dialogue regarding other projects and assignments. The process was iterative; we continually reassessed our methods, our research questions, and our role in the development of AV. Due to the nature of the Silicon Valley work culture, the HUD team was in constant communication with our coworkers and by extension other departments at NRC-SV. This meant that we were always working with the software engineers and designers creating the back end of the AV platform. This gave me more insight into the world of the employed corporate anthropologist embedded within a company as opposed to the consultant role.
Thanks to my working with both Melissa Cefkin and Brigitte Jordan I had access to their combined experiences in the field and industry. This was, for me, one of the most important things I gained from working at NRC-SV. By seeing the placement of these two individuals within the company I got an idea of what it is like to work continuously for one company or organization rather than consulting on a project by project basis. Working for a permanent team in an organization helped us manage the work load, because we knew that anything we wanted to further investigate could be put off for future study rather than needing to be rolled into the present investigation. The opportunity to be a part of an ongoing team greatly reduced the stress of the work because while lines of inquiry were always multiplying, they could be postponed when the mainline project work picked back up.

I concluded my time at Nissan with a brief presentation at an “all hands” meeting where I discussed the work we had done with a specific focus on the ideas of locality and teaching the AV to be local. My presentation caught the attention of the whole office and really helped to showcase the Human Understanding in Design team’s summer accomplishments. Working with a team and presenting on behalf of that team as an intern was a bit of a daunting task. I was not only representing myself or my own work, but the work of others. I am proud to say I did well, capturing the attention of the Lab director and key individuals in other departments who had limited experience with the type of work anthropologists can do in their industry.

Even before the presentation, I cannot count the number of times a coworker would see me doing video analysis at my desk, or running out to my car with camera rigs and ask me what I was doing or what we were working on. After the presentation, the questions shifted from “what are you doing?” to “what else did you find?” For me, that meant that the presentation
really got through to them and communicated the worth of design anthropology in their process.

The process of writing this thesis and doing the work itself solidified several of my potential career decisions. First and foremost I have realized that I highly prefer the life and research style of the corporate anthropologist rather than the scholar-practitioner consultant. The second is that a more integrated and holistic view of research problems and engaging with the subject in real time allows for more focused and relevant findings than studying these phenomena in a theoretical vacuum. What I mean by this, is that this study benefited from proximity to the auto industry. Access to detailed information about the activities of the lab’s engineers and designers allowed us to make informed research decisions that we otherwise would not have been able to make if we lacked knowledge of current projects. I say this in comparison to the Design Anthropology course’s work with NRC-SV, where we did not have access to the engineering and development staff or the other current events of the lab. This limited the focus of our study and our recommendations. In contrast to the circumstances of the Design Anthropology course, my work with NRC-SV happened within the organization and thus in parallel to the work being done by other departments. Our position embedded within NRC-SV allowed the HUD team to give targeted and relevant recommendations specific to the goals of the lab as a whole.

In hindsight I am proud of my work with Nissan and as I write this reflection, it is hard to believe that the process of writing this document is coming to a close. It is difficult to be able to call such a work complete. As I have approached the completion of this process I have found myself continually going back, wanting to add more, but I have said what needs to be said and
made my point. Being at the forefront of a technology that may very well reshape transportation has filled me with a sense of responsibility to “get it right” so to speak. But the purpose of this document is to set a foundation for others to build upon; this work is meant to move the conversation forward about how we may incorporate a new kind of road user into the system of road use. I feel that I have contributed to a groundwork that leaves openings for further research and inquiry into the impact of the AV on society, and the design insights that can help to better integrate AVs as road users.
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