Don't Make Me Automate! Students Find Themes of Trust and Discovery Examining Drivers' Experiences with Existing Automation

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Introduction and Overview of the Literature

The role of the car in technological innovation was established early in the 20th century. Roland Barthes – a French semiotician renowned for his examination of bourgeois culture – captures the emotional appeal of this innovation in his description of the Citreon: "It is obvious that the new Citreon has fallen from the sky…the bodywork, the lines of union are touched, the upholstery palpated, the seats tried, the doors caressed, the cushions fondled; before the wheel, one pretends to drive with one's whole body. The object here is totally prostituted, appropriated: originating from the heaven of Metropolis [4]."

Barthes' early account presents the car as a divine creature which humans have been granted control over. Yet, this now familiar interaction between humans and cars is currently in the midst of a rapid transformation – characterized by the transferal of power, control, and agency from man to machine. With a range of autonomous features including adaptive cruise control (ACC), lane-keeping, assisted parking, blind-spot detection, and even 'Autopilot' being introduced in nearly all new models from auto manufacturers, humans are becoming more comfortable with taking their feet of the pedals, hands off the wheels, and passing important decision-making and execution functionality off to their cars.

As in the evolution of any relationship, this transfer of judgment will lead to new and distinct patterns of behavior and cooperation between drivers and their vehicles [13,14]. While appropriate user-centered interaction models have been studied [12], no in-depth observational study detailing these changes in behavior and interaction – particularly with a sharp focus on the emotional component - has yet been conducted [7, 18,11].

A growing body of evidence indicates that the future of the driving experience is evolving quickly; few dispute the notion that autonomous developments will forever change our relationship with cars [6]. How will autonomous changes affect the driver? Today, driving will benefit from research and engineering deign of emotion-capable systems [7] with new urgency and fervor [7,3] distinguishing emotional expression for communication from emotion as a mechanism for the organization of driving behavior [2] and wonder if cars are making decisions on our behalf .

The experience of driving is an intense, emotional one, historically rooted in the American notions of freedom, self-expression, and personal ownership. While many objects can produce profound and complex emotional relationships with their human counterpoints, few do so with as much success as the automobile. A fascination with cars makes people talk passionately, and relate to cars in ways unlike any other object. The

result is an intensely emotional experience where people tell car stories differently than any other story [22] .

Aesthetics, and human fit is well documented in the consideration of car design [1]. The practice-oriented, popular literature gives considerable attention to how to motivate teams to build the safest cars, yet recent academic research suggests a somewhat different angle, focusing instead on influencing emotional responses during the driving experience[10]. While many discussions and narratives of autonomous driving fantasize about a fully-autonomous experience (one that is likely decades away), the driver's experience using *current* features of vehicle automation has received little attention. Most of the existing work considers specific technology, or defines emotion as a connection to human performance, safety and efficiency. Discussion often considers the benefits of autonomous driving, or theories based on the parallels to piloting an airplane [16]. Recent work introduces the notion of comfort and fun in the discussion of excitement around the automobile[27,28] from Faurecia, Ford, Fiat, and others.

The work presented in this paper began with a fascination for cars and car stories, and some observations about the practices which link the characteristics of the person to their the experience of driving their car. The preliminary phases of this study drew parallels from psychological theory on emotion to driving experience with automation. The goals were outlined to both search for understanding 'driver behavior' and potential use for that understanding to attract, assess, and design for the global 21st century driver. Thus the work presented is an attempt to take a closer look at the driver's experience through the collaborative approach of two disciplines - engineering design and psychology - and to utilize the intersections of these fields to understand the driver of the future.

The current research is an observational study and focuses on classifying and decoding the emotional continuum of users incorporating existing automation features both their personal vehicles, as well as cars chosen for driver experience observation. The present work tells the "drive-along story" through students' perspectives after examining videos of test drives of both personally owned cars, and of new cars during dealership visits. The observational study research [21], conducted in a graduate level course in the Department of Mechanical Engineering at a west coast university in the United States, developed a preliminary approach to analyzing the drive-along responses - videos, audio, and pictures - of test drives. By more completely understanding the emotional experience of interacting and communicating with semi-autonomous and autonomous vehicles, we include graduate students in the study of emotion to equip them as designers with better tools to ensure a successful transition into the next evolution of human-car interaction.

Participating graduate students were enrolled during the autumn 2015 term, in one Mechanical Engineering class, with a focus on defining emotion along with consideration of the automobile. The class included car enthusiasts and non car-enthusiasts. A significant portion of the curriculum content included a theoretical definition of emotion defined in its broadest sense [21] to characterize and classify emotions with the intent to guide students during observation and reflection, and to prepare students to build

preliminary insights from their reflections. Detail provided in a later section, "Students Watched Videos for Preliminary Assessment."

The general purpose of our study is to understand the user experience of driving a fully or partially autonomous vehicle. We also seek to investigate designing emotion – that is cultivating and observing emotion while driving -- and find interface interventions that might help ameliorate issues with attention, trust, discomfort, and sensing connection as engagement. This on-the-road observational study method is intended both to examine and visually explore the intensely emotional experience of driving while validly complementing similar studies that take place in our campus driving simulator laboratory. This method allows us to examine important contextual factors like situational response to pedestrian crowds and road traffic, which is far more difficult to examine in the lab simulator environment.

In this study, we are trying to understand and visually explore the driver's experience to partially autonomous features in the vehicle. Overall, we hope to understand how to improve drivers' understanding of and comfort with autonomous vehicle technologies by utilizing the currently available semi-autonomous features available in many modern vehicles. A better understanding of drivers' emotional states in autonomous driving scenarios will allow us to better predict a person's ability to respond to critical events. This knowledge is important because significant advances that are being made to the capability for cars to self-drive have largely neglected human-machine interface issues; the understanding of driver-vehicle interactions is critical not only to human safety and product viability, but also to the future of the mobility story in varied environments.

Method

1. Experiment overview

Our study explored user responses to existing automation two ways: *how* the driver is acting (if or if not the driver is undertaking automated activity) and an assessment on *why* the driver is acting that way based on graduate students observations of the videotaped results.

Within this observational study structure, we examine driver's stated and physical responses to using (potentially for the first time) the automation in their vehicles, including cruise control, acc, semi-autonomous pilot, and back-up assist.

2. Participant Selection for Preliminary Investigation of the Study

The original 8 participants in the study were selected to include both males and females, provide a variety of car types, with some form of car-assisted technology. The original sample included 5 female participants and three male participants. Since the preliminary investigation, 4 additional participants, 3 male and 1 female, have been added. All were adults, with a driver's license and ranged in age from 19 – 59.

Graduate Students Qualitative Assessment
Three parts define the assessment conducted in one graduate class:
Part 1 - Students individually review and discuss first impressions as a group.
Part 2 - Students respond to questions in the moment, while watching the edited videos
co-authors observe student audience response.
Part 3 - Students receive pre-work for a follow-up discussion.

Car Driver identification and Interview Questions

The eight driver-participants featured in the discussion of results in the study were
selected because they: 1) volunteered to be part of the observational study, 2) were
personal owners of cars, 3) recognized challenges in semi-autonomous driving.
The Tesla drivers, the Audi drivers, the BMW driver, the Mazda drivers, and the Fiat
Drivers were chosen with the intent to maximize varied car ownership, background and
opportunity to paint a picture of the car driving experience an illustrate emerging
emotional elements as attributes.

Cars on campus and in surrounding neighborhoods were identified because they appeared
to have autonomous features. Flyers were left on the windshield of 30 cars stating:
*"We are conducting research in the Department of Mechanical Engineering on people's
experience driving cars. We would like to interview you and your car.
Please contact ____ below to schedule a brief conversation."*

Interviews were conducted by the co-authors using a two part semi-structured
interviewing technique for pre and post interviews that was consistent across
participants. All interview meetings began at the participants' driving location. The
average meeting time for each interview was forty minutes. The longest interview
consisted of one hour and fifteen minutes and the shortest interview lasted thirty minutes.

The interviewers purposefully and strategically used a video-taping technique through a
planned and professionally guided type of Go-Pro camera template applied through a
team approach. While testing without taping requires careful note-taking and rigorous
attention to data and immediate follow-up details for coding techniques, interview results
reveal more comfortable discussion and open story telling. However, since the purpose
of the current study was to observe responses to visible car assisted technology, the use of
both video-taping and note taking was necessary. The current approach captured
sensitive and in-the-moment emotional data that might otherwise have been unlikely to
surface. A release form was offered and signed by all participants in videos used for
educational purposes (shown in classrooms, at scientific meetings and conferences)
release form. Participants' identity and geographic locations were modified in composite
descriptions.

Facilities for Preliminary Investigation

The study takes place in the parking lot of the extensive car invention lab located on the Stanford campus and surrounding public roads. As participants' drive-along and around the planned course area, video, participant responses to existing automation and vehicle operation data is collected continuously and later saved onto a password-protected laptop computer in the car. After the study, the laptop is generally stored in a locked laboratory facility at the primary research facility; at times the laptop can be moved off-site for analysis, but it will only be accessed by researchers with password access. (Note: For future study exploration, some of the video, as well as pre and post-interview data, will be uploaded to the research platform application Dedoose.com. Dedoose utilizes the highest standards of data encryption and protection available for web-based applications, and uses project-specific encryption to increase the security of data uploaded to its site).

Study Procedure

During a first meeting, participants were observed to assess factors such as their driving experience, driving style, and prior experience with automation and media technologies. Following the pre-test, a pre-interview was conducted with the participant, prior to the driving portion of the study, using their personally owned automobile. Student researchers, using previously determined and modified templates for Go-Pro placement along with hand held Go-Pros, first ask a series of previously determined questions. Then during the approximately 30 minute drive-alongs the researchers offer guiding questions to the driver. The "drive along" experience is designed to facilitate the driver's narration of the driving experience with partially autonomous and autonomous features.

The participants were informed that the Go-Pro set up is meant to capture their responses to the existing automation (on the driver's sometimes first experience with visible and existing automation in their cars (e.g., ACC, assisted back-up, lane keeping). The interviewers purposefully and strategically used a video-taping technique with a series of Go-Pros affixed to capture of the driver face, the dashboard, behind the driver's head, and the passenger. Participants were informed that the videos would only be used for educational purposes – in the classroom and in the lab and at scientific conference presentations. Participants also signed consent forms.

The research vehicle varies because it's the participant's personally owned car (in almost every case). All drivers are licensed. There is a separate researcher in the back seat that monitors the driver's reactions. This researcher controls the timing and type of physical cue that the participant receives. The participant is in the driver's seat. The Go-Pros are positioned to capture responses and movements at the steering wheel, the visual dash display, and the driver's road view.

After being given an ostensible destination and task, the participant "drives" in the designated campus invention lab parking lot and/or roads, and asked to perform primary activities (entering the car, getting comfortable in the driver's seat, starting the car) as well as secondary activities (engage cruise control, ACC, lane keeping, and/or

autonomous pilot). Participants are encouraged to discuss entering the car, how they feel at a stop, or if turn is coming, and to talk aloud about questions or concerns they have about the drive. In some situations, the participant may be asked to try using a feature for the first time (e.g. cruise control or acc). This task is designed to test their reaction to using or trying existing automation in their car. At no time is the participant requested or pressured to use their existing car automation features if they do not wish to do so. The participant is being video recorded for the full duration of the drive. He or she may ask to stop the drive-along experiment at any time.

Following the driving course, a post-interview is conducted with the participant. Pre-determined questions focus on their driving experience, their assessment of aspects of the driving interaction and interface, and their recollection of various aspects of the drive-along experience and their response.

These research procedures are minimally risky, they are driving their personally owned vehicle, on quiet campus roads or parking lots, and riding a car with "trained" passengers as researchers. Two elements outline ethical consideration in the study:
a. Audio and video recording occurred. The recordings were used to code participant behavior, to examine and transcribe interactions with the existing automation. Additionally, videos may be shown for educational purposes, in classrooms, labs, at scientific meetings, and used to illustrate and promote our experimental platform in public settings. We asked participants for permission to record video before the experiment, and for permissions with regard to the extent and purpose of sharing video following the experiment.
b. Participants are fully informed about the purpose of the study.
We did not employ deception.

Development and Content for Analysis

Analysis of Content and Measures

This research provides a rich variety of variables to study. In this examination, our focus is on observations of the driver's response to entering the car and driving as interaction with specific features. Our observational study uses a qualitative approach, an umbrella term covering an array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency, of certain occurring phenomena [26], or in our case, emotional responses to the drive-along experiences.

Emotion was considered in and defined by expression and perceived private experience [21,9] . For the purpose of our preliminary study, it was important for the respondents to find emerging themes, and assess emotion in the "natural" car-driving setting, depicted in the video-tapes.

The focus: Characterize and examine the driver's response to existing automation. What is the driver's experience during the drive-along?

<u>Students Watched Videos for Preliminary Assessment</u>

The one key thread in our methodology is that graduate students in one particular Mechanical Engineering course, ME 243, Designing Emotion for Car Interface, watched the videos collected by the research team for the purpose of preliminary blind assessment. Students did not receive payment.

Participation occurred in three parts as Qualitative Response:
Part 1 Students individually review and discuss first impressions as a group.
Part 2 Students respond to questions in the moment, while watching the edited videos.
Part 3 Student as audience respond to questions, building a frame for story composites: "Review the videos again, this time, prepare brief statements to develop your impressions on the emotional responses by the participants during the next class."
.

Part 1 - Students individually reviewed and discussed first impressions as a group. A list of reflections-as-emotion in their responses (class exercise referred to as Car Story Responses) to the car videos included the following words and word phrases: *terrified, stress, nerve-wrecking, nervous but excited, happy, excited by achieving, trust, comfortable, anxious, peaceful, connection to the car, mystery around the car and what will happen next.*

Part 2 - Students respond to questions in the moment. While watching the edited videos co-authors observe student response.
Videos were presented during class. Students were encouraged to observe and reflect on what was visible. Preliminary insights from reflections as emerging themes and images were compiled in response to a series of questions featured in Table 1. The themes that recurred most frequently to the questions asked were the ones chosen to base our analysis. These three overarching themes: Discovery, Trust, and Sensing Connection as Engagement are considered in the Discussion section.

Part 3 - Students receive pre-work for a follow-up discussion: "Review the videos again, this time, prepare brief statements to develop your impressions on the emotional responses by the participants during the next class."

The story of our research, developed by a co-author and graduate student in the class, captures both the process of the drive-along experience and the student response to driver interaction:
"They entered the car, keys into the ignition, or sometimes just a press of a finger. Beep beep beep beep. Seatbelts on? The peculiarities of habit made visible when under the scrutiny of a camera. Not one but four. We'd be monitoring all aspects of this drive – subtle facial cues and body language, interaction with the car's interface system, the road itself.
As they drove, they told us their stories. We observed and we asked questions, but mostly we watched. Let them do the talking. Lean into the silences. And when we asked them to try out an autonomous feature of their car, that's when things got interesting.

How exactly does a human in control of a car feel when letting go? Do these new features that pave the way towards fully autonomous vehicles amplify or atrophy human ability. What does it mean to trust an object, to "sense and feel a connection" to it, to discover it?
We had graduate students watch the videos we collected and blindly assess them. These are the themes that recurred most frequently from our questions, and the ones that we've chosen to base our analysis around: Discovery, Trust, and Sensing Connection as Engagement."

Questions During Drive-Along	Graduate Student Questions
1. What is your experience entering and in the car?	1. What are your first impressions watching the video?
2. Which features do you use?	2. What emotions were evoked in you while watching the drive-along videos?
3. Are you willing to try the cruise control (or ACC depending on car)	3. What do you think will happen next?
4. Show us. Tell us more about your driving experience with or without…	4. Thoughts on the driver experience?
5. What did you like about the drive?	5. What are some implications for designing emotion for any product?
6. Was there a question you expected but we didn't ask?	6. What would you like to see featured in the edited videos?
7. Any surprises?	

Table 1   Questions during the Drives and Questions asked to graduate students watching videos

Assessment Content

All graduate student participant responses to the driver experiences were listed.
The analysis of the content of responses indicated three themes:
a. <u>Trust</u>: Defined by images on two levels: acceptance of the interview process and of autonomous features in the car (e.g. ACC). Phrases include specific mention of the concept of comfort, determined and ready or presence of trust. She said, "I just don't trust myself with it." Or, there was a suggestion of presence or lack of trust. When he wrote, "Yea, maybe not, (in reference to using cruising control). "Once I use back-up assist I will trust it so much, there will be no going back."
b. <u>Discovery</u>:   Defined by images indicating a first time use, finding, assessing or trying something new. Phrases indicated both verbal and non-verbal cues. When he was driving he gasped, "Whooooa." Or, one driver claimed he knew how to use auto-assist because his wife taught him, and then appeared clearly surprised by the discovery stating, "Cool." It was clearly the first time he used it.
"I don't know how to use the cruise control, do you?"
c. <u>Sensing Connection as Engagement</u>: Images indicated feelings like you are included in the driving experience, engagement defined as connection with the car driving experience, and/or connected to the car. Relevant here, a visiting automobile design

leader asked the students, "After you park your car, do you turn around and look at it? If so, then I have done my job." Phrases from the students included, "As soon as he entered the car he knew what to do and felt like it was an extension of him." "She looked so confused, and couldn't even sense where the seatbelt was." "He kept turning around, and looking in the rear view mirror, didn't he connect at all with the back-up assist?" The co-authors recognize that further development of assessment content will consider the fact that the more drivers become comfortable with the autonomy of their vehicles, the more they may believe they are granted the luxury to become less engaged. In this regard, analysis would further consider what it means to be *less* attentive to the inputs and contexts that, previously required human dictated actions.

Table 2 summarizes three independent elements, Discovery, Trust, and Sensing Emotional Connection as Engagement, as attributes, assertions as number of measurement items, and associated research models.

Analysis of video-taped interviews were coded by the authors and reviewed by graduate students in one mechanical engineering design methods course: students blind to the assertions of the study. All elements as attributes of driver responses were compiled and coded (see Table 1). The researchers took notes during the car "drive-along's" and after the pre and post interviews and wrote the details of their stories immediately following each interview.

Findings, reported as emotion drive-along composites in Table 3, were written after completing: original drive-along's and pre-and post interviews, and follow-up notes and conversations with the graduate student coders.

Table 2
Assertions Model

Independent Driver Response Attributes	Items	Research model reference
Discovery	3	Miller et al, 2015; Sirkin, 2010; Mok et al, Srinath, 2015 Nass, 1994; Nass, 2013,
Trust	2	Ganjoo, 2005; Miller et al, 2015, Sirkin, 2014; Brown, 2014
Sensing Emotional Connection as Engagement	3	Ekman 1984; Cialdini, 1998; Sebe, 2007; Karanian, 2007

Preliminary Findings

Drive-Along Story Composite Results

Questions during the drive-along and to the students assessing the videos are shown in Table 1. Analysis of extensive graduate student response to video-taped interviews were coded by the author and reviewed by another group on campus blind to the assertions of the study. The researchers took notes during the drive-along interviews and wrote the details immediately following each interview.

All story composite identifications were noted after completing: the drive-along interview and multiple opportunities of observation and discussion where the co-authors presented the video-taped findings to graduate students. Discussions helped detect, describe, decode, and translate responses during and after the drive-along experiences.
One graduate student reflected on her assessment:
One of the drive-alongs that stood out to me the most was the video of an older man using some of the adaptive cruise control features in his Tesla. The first time that I watched this video, I didn't pick up on much past the basics; I took a lot of what the driver said at face value. However, after listening to things that my classmates pointed out, I was able to recognize plenty of interesting nuggets by paying more attention to the driver's language and how exactly he interacted with the features in the car. I noticed that even though he said used the adaptive cruise control in his car, he did not actual use it with the comfort level of someone who is familiar with the feature. I noticed something new each time I watched the video, which really highlighted the value of this tool.

Another student reported:
Fascinated by driver interviews presented in class where different drivers expressed their levels of comfort with backup cameras, cruise control, and in one instance, Adaptive Cruise Control. These videos typically showed an under-reliance on the automation features in that few drivers knew how to operate them even in situations where they could be beneficial. On the other end of the spectrum, Tesla Autopilot videos where users were blatantly ignoring safety guidelines by not paying attention to the road and the incident where one user was paying enough attention when Tesla Autopilot nearly swerved into oncoming traffic as well as Audi "water bottle override" video for its automated highway driving. To me, almost all of these videos were incredibly obvious examples of over-reliance on the automation feature and, in the "water bottle" video, was even an instance of a user finding a workaround to an implemented system designed to prevent such over-reliance.

All eight subjects featured in the results were coded with the results as story composites for the presence of the three assertions proposed. Table 3 presents a list of story composites by car and driver identity, and number of featured attributes (Discovery, Trust, and Sensing Connection as Engagement). The first story composite, The Tesla driver is the only one that extensively considered multiple attributes of each assertion. Specific attribute examples for Discovery, Trust, and Sensing Connection as Engagement are featured in mini story composites for the remaining participants. sensing connection,

imagination, expansive world view, expecting confrontation, and character are briefly featured in mini story composites for the remaining five participants.

Table 3 presents a listing of the three assertions story composites by identity, and number of featured attributes described. In other words, one driver of a Tesla, three Audi 4 drivers, a BMW driver, two Mazda drivers, and one Fiat driver were observed for fitting the one or multiple or all assertions in the model.

All participants featured in the results were coded for the presence of drive-along assertions in the proposed model. The first story composite, The Tesla driver is the only one that extensively considered multiple attributes of each assertion. Specific attribute examples for discovery, trust, and sensing emotional connection as emotional engagement are briefly featured in mini story composites.

Table 3 presents a listing of five story composites by identity, and number of featured attributes described.

Table 3
Story composite dimensions by Discovery, Trust, and Sensing Connection for driver (in development)

Identification	No.	*Assertions Featured*
The Tesla Driver	3	Extensive illustration of all
The Three Audi Drivers	2	Sensing connection/eng, Trust
The BMW Driver	2	Sensing connection/eng; Trust
The Mazda Drivers	2	Trust, Sensing connection/eng
The Fiat	3	Trust; Discovery; Sensing connection/eng

One "unlisted" edited video (link is required to watch it) features driver interactions.
https://youtu.be/9wMqbq9zjsQ

Discussion of Assertions

Discussion of findings show responses as three emerging themes, Trust – color coded as yellow, Discovery- color coded as blue, and Sensing Connection-color coded as red on a spectrum ranging from low to high. Assertions for each are outlined below.
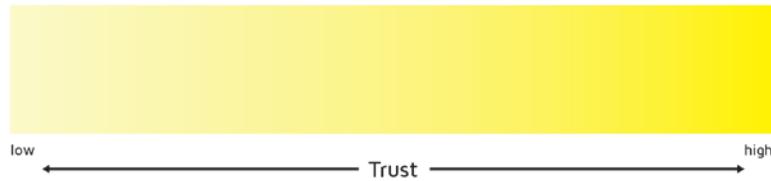
Trust

Assertion 1a
The more pronounced the trust of the driver, the more amplified their opportunity is for accessing, finding, and trying the autonomous features.

Assertion 1b
Communication of the trust for experiencing autonomous features for the driver begins as non-verbal actions and verbal responses and ends in utilizing new technology and design.

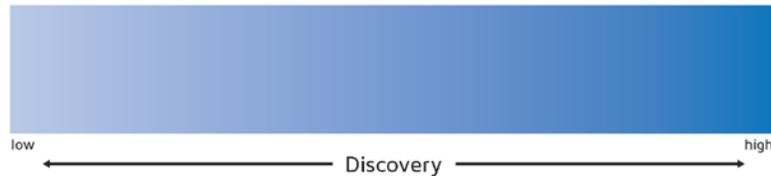Graph 1   Trust color coded yellow feature low-high participant response during drive-along's.

Discovery

Assertion 2a
The more vivid the trust of the driver, the greater the chance for discovery of something new.

Assertion 2b
Resisting the experience of trying the autonomous features is evidenced by paralanguage cues (groans) and verbal reflections of worry.

Graph 2 Discovery color coded blue feature low-high participant response during drive-along's.

Sensing Connection as Engagement

Assertion 3a
The role of connection, and the capacity for sensing connection is evidenced in the driver's unique capacity to engage with the car, from the moment they enter the car. This includes opening the door, the process of sitting, buckling up, looking in the mirror, and making thoughtful glances around the interior and exterior of the car.

Assertion 3 b
The unique responses of the driver includes gender as an element in connection as both a way of knowing as expectation for what happens when they enter the car, and as a driving experience and responds accordingly.

Graph 3 Sensing Connection color coded red features low-high participant response during drive-along's.

One observation worth noting is the sequentially reliant nature of the three themes. Given the definitions appointed above, the themes of 'Trust', 'Discovery', and 'Sensing Connection as Engagement' are noted in high responses from participants most noticeably one after the other, such that the increased response of one is largely dependent on the increased response of the previous theme. i.e. a participant is highly unlikely to show willingness to 'discover' without a strong sense of 'trust' in the capabilities of his or her vehicle, and – in turn – a participant cannot 'sense connection as engagement', without some high degree of discovery for one or more semi-autonomous features. This reliance of themes building upon each other can be represented by a growth curve, as in Figure 1. Increasing amounts of trust contributes to a period of rapid discovery, which – in turn – contributes to a significant increase in sensed connection as engagement.

Additionally, high responses or 'gains' in each of these themes is contingent upon multiple experiences in which a driver may familiarize him or her self with the features afforded by the vehicle and thus reinforce comfort with them. While many of the semi autonomous features in cars are quite simple to learn and use (and can likely be completely comprehended in a single trip), the key to high responses in trust, discovery, and sensing connection as engagement is using multiple trips or data points to fortify the original trust these features can improve the driving experience and the driver's sense of connection and engagement in his or her vehicle. This period of multiple trips in which the features are utilized initially can be considered a 'Discovery Period" (see blue shaded area of Figure 1.) in which a driver will show increased responses for both trust and sensing connection as engagement simultaneously.
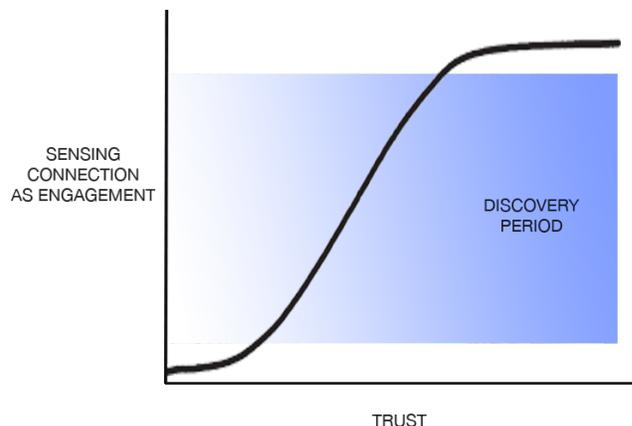

Figure 1.

Student Response as Discussion of Driver Experience

In our study, we explored user responses to existing automation two ways: *how* the driver is acting and assessment on *why* the driver is acting that way based on graduate students observations of the videotaped results. We set out to focus on trying to find ways for graduate students to assess and attach meaning to real-world challenges of auto-assist driving. Tangible discoveries are tough to fully define due to the preliminary nature of the work. Findings indicate that graduate students characterize and examine the driver's response to existing automation with themes of trust, discovery, and sensing connection as engagement.

In our examination, we include examples from the drivers in story composites and discuss themes emerging from graduate student assessment. This section details what we do know about the student responses of their assessment of the drive along experience, informed by relevant research.

Some of this work was initially inspired by an exercise in using the backup sensors in a Fiat vehicle. Intuitively, first-time users rely less on that system than more experienced users which implies a level of trust in that system. One student ironically noted, "There's no going back once you use back-up sensors." Related research influenced the development of the model and assertions of discovery, trust, and sensing connection as engagement. Given the importance of emotion in developing trust, research on Emotion-Capable Robots detailed perception on different types of emotion such as energy-based and object-based[7]. In the context of automation features and trust, we can identify the benefits of the automation features based on these classifications of emotion. For example, there are emotions associated with not wanting to be in an accident, classified as a negative event – from fear for personal safety to desire to keep one's car in good condition (object-based) to not wanting to cause damage to another's vehicle (confrontation-based). However, consider a person late to an event, they may be willing to forgo some of the emotional benefits of avoiding an accident for the social emotional benefits of arriving on time. In the case where the user's vehicle has some level of automation, the level of this tradeoff will be largely dependent on the user's trust in the car's features. Conversely, the user's development of trust in the car will be based on the car's ability to provide the greatest benefit to the user's emotional wellbeing.

Similar to the work by Jung and Sirkin [13] where one aspect of trust and emotional well-being was considered in the case of range anxiety in an electric car, the current work addresses a problem that all drivers face – strong feelings about using existing automation- or in the cited case - anxiety that one's vehicle will run out of gas/charge before reaching their destination, the current work recognizes a resistance to trusting existing automation. While the current work does not focus on range anxiety, an interesting parallel exists. Considering that typical mileage estimates give the number of miles left based on recent road conditions, 100 miles left might only be 10-20 once one approaches the uphill climb during the final leg of a drive. We can recognize this objectively, but in the moment, when the car is putting forth what appears to be a highly precise estimation the driver is forced with a choice of either trusting the mileage estimate or trusting the car's ability to be energy efficient enough to reach the destination.

In the case of the former, their findings indicated that drivers feel that cars are effectively "lying" to them when the range estimations. By avoiding the driver's perception of being lied to (in this example, by intentionally making ambiguous fuel estimations to represent it as a guess instead of a fact), the authors note an ability to avoid the resulting loss of trust in the vehicle as well. Relevant here is the work on machines and mindlessness, Nass and colleagues considered the importance of "Reciprocal Self-Disclosure" where people are more likely to share intimate details if they first become the recipients of such disclosures [13]. The idea that people are more trusting when they first feel as though they have been trusted with some information may inform the time it takes to trust existing automation, and the degree to which a person trusts using for example, cruise control. What if this trust is in the form of a machine's willingness to share its uncertainty with the user [13]?

Research that attempted to quantify trust[9] achieved informative results, and sheds light on what the current research hopes to accomplish. By repeatedly giving users trials where automation features performed successfully and unsuccessfully, they were able to find some quantifiable level where user trust. This was based on a set situation where the feature could be trusted to perform successfully. While our observational study indicates findings as emerging themes, as emotions in a broad sense - of Discovery to Trust and Sensing Connection as Engagement - during a driver experience with existing automation, they showed how successful performance of an automation feature served to reinforce a user's trust in that feature as well as how unsuccessful performance decreased trust. However, when considering most actual automation features, most users will never experience an unsuccessful performance. This may be beneficial for the quality of automation, but presents the disadvantage that many actual users will never recognize events in which automation should not be trusted before they are in that situation. Researchers tackled a similar user reliance issue, but instead tested the level of user reliance based on level of automation available[15]. They found that as automation increased, users were not only more reliant on the system as expected, but they were also more likely to be over-reliant.

Our work provides similar insight to the above mentioned research in a different context: A user's perception of the quality of the automation will ultimately slip away when that automation cannot perform up to a user's standards in a given situation if there isn't a strong degree of trust within the driver, minimizing the chance for discovery of something new.

Videotaped drive-along results triggered student debate during classes about the role of emotion. Students were sure they could out smart the automobile's autonomous system. In one example, discussions considered planned actions to combat over-reliance, like turning off the semi-autonomous feature. One student even suggested attaching a post it note reminder on the dashboard of a car without sensors. They insisted that they could somehow "catch-up" emotionally, and not be behind advancing technology. Another reflection during class was from an owner of a new Fiat with back-up sensors. She relayed the story of renting a car on a trip, an older Fiat without back-up sensors. The class guessed the frustrating outcome: when the driver put the car in reverse on a long, dark driveway, she was behaving "as if" - as if she was in her car with back-up sensors;

she backed up into a plastic recycling bin and shattered a rear tail light. While back-up sensors are not specifically an illustration of auto assist, a parallel point was made.

Graduate student assessment of the videotaped responses surfaced relevant information about their personal experience with driving and owning an automobile. They indicated that they often share their cars, or borrow a friend's car on campus to drive the hour to the city, to an interview, or on a weekend road trip. This factor is both informative and limiting to our finding of "discovery" and especially "engagement." During a first time use, there wasn't a focus on trying something new. Nor, they explained, did they have the time to form a connection to one car, or what it looked and felt like. They learned the feel of a car over and over again when they borrowed another car. During discussions of student responses to videotaped drive alongs, they explained that most of the time, they just wanted to get from point A to point B; and unless they already knew it, they didn't have time to learn ACC or auto assist features in other people's cars. In this context, our study definition of engagement as - *images indicated feelings like you are included in the driving experience, engagement defined as connection with the car driving experience, and/or connected to the car* – is limiting.

What if sensing distraction, not connection, becomes engagement?   Informative work found that distraction, in fact, became engagement in automated driving. [29]
The responses by the graduate students, suggesting that there may be distinct generational patterns of behavior and approach between drivers and their automobiles, will impact the current study's definitions of trust, discovery, and engagement. Thus, what happens when the driver is caught by surprise? Timing is everything; examining driver surprise is one way to further expand our analysis. [30]

Implications for Next Steps

Findings indicate that during semi-autonomous drive-along experiences responses show a sequentially reliant nature of the three emerging themes, presented as emotions of trust, discovery, and sensing connections as engagement. Our study is based on a very preliminary consideration of the semi-autonomous driving experience, in limited context, and with a few car types.

The utility for engineering education study [5] is contained in the graduate student responses and participation with the assessment of the drive-along's. Graph 4 shows a color-coded gradient display of yellow (depicting Trust), blue (depicting Discovery) and red (depicting engagement) ready for the potential of a deeper analysis. The degree to which Trust, Discovery, and Sensing Connection is present in the driver experience offers an opportunity for an exploration in analytical thinking and creative expression in student work. Questions emerge: How will the themes and images be translated? Assessing how the graduate students know the themes of trust, discovery, and engagement- defined as emotions in a broad sense - when they see them (on the videos) offers lessons in construct validity; and diverse ways understand expressing differences. What specific phrases and qualitative phenomena define low vs. high on the spectrum of response for the themes of trust, discovery, and sensing connection?
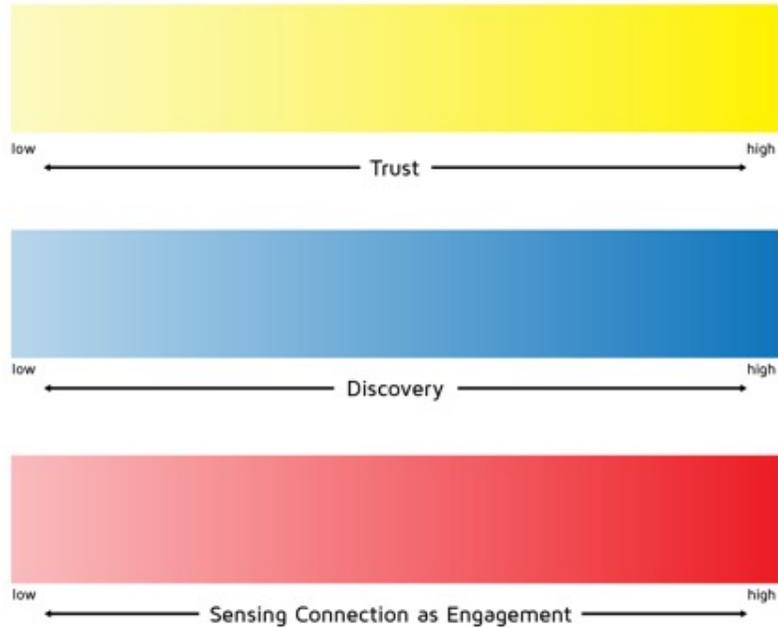
Graph 4 Color-coded bars feature low to high spectrum for Trust, Discovery, and Sensing Connection

During a follow-up discussion considering the significance and meaning of the current work, students provided a detailed list for strategically planning next steps. They suggested:

- List automation into safety related and non-safety
- Group automation in to basic and advanced feature
- Group automation in to table stakes and special feature (marketing perspective)
- Identify the driving technology behind the automation
- Identify the human sense being augmented when relevant
- Explore origin of each automation
- Explore cases of failure
- Rent a car with most if not all the features (a top end car usually has all)
- List out systems that can be effectively tested on controlled track and/or on-road
- Drive car for at least a few hundred miles to experience the testable automation
- Design a study with multiple participants using same car
- Report using video montage of recordings
- Define assessment from both researcher and students in class perspective
- Examine difference in assessment responses by car enthusiasts vs. non-car enthusiasts

The current work suggests that further analysis is necessary to consider whether or not there is a point to be made that, as we become more comfortable with the autonomy of

our vehicles/as our vehicles supplement our own abilities, we as drivers are granted the luxury to become *less* engaged? Are we *Less* attentive to the inputs and contexts that, previously, required human-dictated actions and responses? Isn't part of the objective of autonomous features to allow humans to delegate our power, so that we can enjoy the *reduced attention and engagement* that non-autonomous driving previously demanded? Therefore the definitions of the assertions of trust and discovery, and the observation of the sequential nature of the assertions, of the themes building on each other requires more development and observation.

Additionally, since our study examined user responses to existing automation two ways: *how* the driver is acting and an assessment on *why* the driver is acting that way based on graduate student observations of the videotaped results, a deeper look into student observations is necessary. We recommend a careful consideration for both defining course content for student observations and for compiling student observations. While offering an intriguing first attempt, the current analysis is limited in its approach and opportunity to detail student insights. We close with a graduate student response on the analysis of *how* the driver is acting and the assertion of engagement: "Or maybe this is the sweet spot, the difference between semi autonomous and full autonomous. An inflection point, if you will -- semi-autonomous grants us trust in these new, semi-autonomous 'superpowers' that enable us to extend our abilities when engaging with a car; fully autonomous gifts us the luxury of inattention at the price of engagement."

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