LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Department of Psychological and Behavioural Science

"Autonomous Vehicles: introducing a new actor in the market"

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MSc Programme: **Psychology of Economic Life**

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Assignment:
You are a member of a group of experts [your working group] consulted, on an economic issue currently occurring ["the case"], by one of the major stakeholders (e.g. government, key industry player, consumer association…). Your working group must produce its report by early December in the form of a 5000 words report. 3 intermediary presentations of the progress of your work are planned with the stakeholder. The final report must be 5000 words max.

The final report should include a short background description of the case (1000 words max, not included in the 5000 words], a clear statement of the questions the group addressed in the report, a brief review of relevant literature in the domain of the case, a theory literature review presenting and discussing the theories most relevant to address the case (accounting for what happens) and how they apply. Finally, based on the literature above and justified by it explicitly, some recommendations for the stakeholder. These recommendations should foster sustainability.

The reference list (which must follow APA rules) is not included in the word count. The background description does not count (but must be less than 1000 words). Tables count. You can add supplementary material in appendix but no more than 20 pages.
The intermediary presentations in classes do not count for the final mark: they are part of the work and not intended for evaluation.

NB: This essay is the actual assignment piece produced by the group; before receiving marking and feed-back. It is not a report, does not commit the LSE, and is provided ONLY as an example of what is produced in the group work in PS465 for the benefit of future students. Remember they were written only in a couple of weeks during an already intense term, by students with no previous knowledge of the domain.
The assessment consisted of this group essay, of an individual MCQ and of an individual essay (this year, a reflexive piece on lessons learned in the group work).
This essay received a good mark in the (double, blind) marking.

Background description: Start the engine

The future has arrived; autonomous vehicles (AVs) are a reality. As of October 19, 2016, all Tesla vehicles have the hardware and software needed for full autonomous capabilities (Tesla, 2016). In 2017, Tesla will market the first full AV (Stewart, 2016). AVs potentially offer a solution to accidents, congestion, and pollution. However, many are not prepared to welcome AVs onto the road. Therefore, resistance to AVs persists, despite suggested benefits. The following consultancy report [supposedly] for Tesla Motors provides advice on overcoming barriers to full AV adoption. Focus is placed on the current transition phase, particularly the driver-vehicle relationship. The background description situates the case by highlighting current mobility issues in the United States (U.S.), the present state of AVs, and Tesla's experience and success.

Automation has increased productivity, lowered costs, and reduced human error across different sectors. Applied to AVs, potential exists to improve safety, reduce traffic, and consequently reduce pollution, all while increasing convenience for the user (Appendix A). Ultimately, vehicle automation has the power to change the future of mobility.

Regarding safety, The World Health Organization (2015) estimates that each year over 1.2 million deaths result from traffic accidents worldwide. In the U.S., 33,000 lives are lost annually in traffic accidents, ninety deaths daily or almost four deaths hourly (U.S. National Transportation Statistics - NTS, 2016). The National Highway Traffic Safety Administration (2015) attributes 94% of U.S. traffic accidents to human error. Personal vehicle passengers are the largest share of total fatalities (35%) (NTS, 2016). By excluding human error factors, AVs are expected to reduce accidents by better predicting and reacting to road conditions.

Regarding efficiency, the U.S. accounts for one-fifth of the world's vehicles (256 million of 1.2 billion) (NTS, 2016). Commuting to work, 86% of Americans travel by personal vehicle (76% driving alone). Only 5% use public transportation. Google (2016) estimates that U.S. citizens "waste" six billion minutes a day commuting. Broad adoption of AVs is expected to increase road efficiency by vehicle platooning, reducing overall time in traffic.

Regarding pollution, the U.S. accounts for 16% of global emissions, second only to China at 28% (U.S. Department of Energy, 2015). Globally, transportation accounts for 14% of total emissions (IPCC, 2014). In the U.S., Transportation accounts for 26% of all emissions, of which 90% comes from petroleum-based fuel, namely gasoline, and diesel (U.S. Environmental Protection Agency, 2016). Reducing time in traffic can reduce transportation-related pollution. Furthermore, the majority of AV prototypes run on electric energy. Therefore broad adoption would reduce fossil fuel emissions.

The concept of AVs dates back to 1939 New York World's Fair, where Bel Geddes envisioned the GM Futurama Pavilion (Computer History Museum, 2014). More recently, the DARPA Urban Challenge (DARPA, 2007) hosted the first competition where AVs interacted with driver and driverless vehicles in an urban environment while following California traffic regulations. Currently, many players are actively involved in creating autonomous prototypes; hardware and software development, and converters for conventional vehicles.

Although some associate AVs with science fiction, many are already present on the road. Google's self-driving car project began in 2009 and so far has covered 3.2 million kilometers (Google, 2016). Furthermore, Uber, a company that hopes to make private vehicle ownership obsolete, began testing AVs in September 2016 (Uber, 2016). Uber also acquired the autonomous truck start-up OTTO, which achieved its first milestone traveling nearly 200 km to deliver 50 thousand cans of beer! (Davies, 2016). Many more examples exist worldwide (Appendix B).

Despite industry enthusiasm, public skepticism persists. Disruptive technologies, notwithstanding the proposed benefits of innovation, ultimately need consumer support. A study from the London School of Economics (LSE) and Goodyear (2016) explored how drivers feel about interacting with AVs. A staggering 60% admitted to not knowing enough about the topic. A survey of 109 countries and 5,000 respondents, found that people's central concern focused on issues related to safety, legality, software hacking and misuse (Kyriakidis et al., 2015). Furthermore, the LSE-Goodyear study found that 73% of respondents fear the system could malfunction. Based on these results, addressing resistance is the first step toward AV adoption, which is the focus of the following report for Tesla, a leading player in the AV market (Tesla, 2016).

Tesla's CEO, Elon Musk, historically pushes the boundaries of innovation and champions sustainability. Musk describes his goal to, “create something that will have a profound effect” as the impetus behind his automobile company (ImagE Native, 2014). Tesla began the quest, “to rid the world of fossil fuels,” by developing the first “compelling” electric vehicle. Musk recognized that changing human nature and instilling a sense of environmental responsibility in consumers, would prove challenging. He, therefore, proposed creating an electric vehicle that departed from the standard image. The path forward involved the creation of a sports car so “hot” that people did not feel like they were compromising.

Building upon the success of the electric vehicle, Tesla works towards creating a fully autonomous vehicle. "Tesla is the leader in electric cars, and we'll also be the leader in autonomous cars, it's going to be the default thing," stated Musk (ImagE Native, 2014). Tesla is poised to build off of the success of their sustainable electric vehicle and offer consumers a product that will fundamentally change mobility. Now, users adopting AVs get the EV as part of the bundle. Tesla is addressing the problem of sustainability with a unique solution, marketing AVs.

Given the background description, the following report tackles the issue of resistance to AV adoption by addressing the driver-vehicle relationship, considered the first barrier for adoption during the transition phase. The report focuses on introducing Tesla's AVs in the U.S. market.

1. Executive Summary

Although Tesla is making great strides in advancing autonomous driving capabilities, understanding the driver-vehicle relationship is key in successfully integrating the technology into everyday life. A survey conducted by the London School of Economics (LSE) and Goodyear (2016) found that a majority of respondents are concerned about the future of autonomous vehicles (AVs). Despite projected statistics indicating that the use of AVs will positively impact safety, efficiency, and pollution, many people are reluctant to relinquish control of the wheel. The following consultancy report aims to highlight specific aspects of the driver-vehicle relationship that Tesla should consider when introducing AVs. A psychological approach is taken using Activity Theory (AT) and Actor-Network Theory (ANT) to situate Tesla within a broader context, considering other stakeholders potentially impacted by AV adoption. Next, Installation Theory serves as a framework for analyzing barriers to AV adoption and proposing recommendations to address these obstacles.

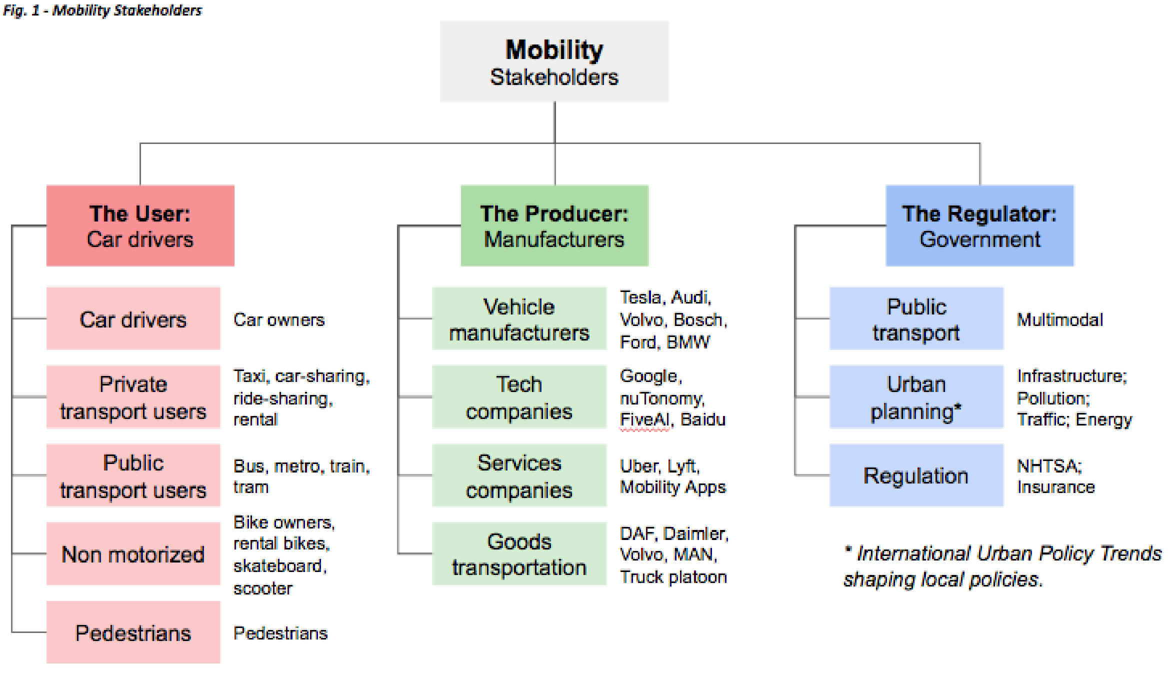
The key constraints identified are, a) technological reliability, b) willingness to give up control, and c) integration into the "social space" (LSE & Goodyear, 2016). The solutions proposed under each constraint are, a) trust based on anthropomorphism and similarity, b) removing driving affordances, enhancing the travel environment, and addressing heuristics & biases, and c) building a community. The report concludes by identifying limitations and future areas of research.

2. Situating Tesla in the Mobility Roadmap

When analyzing introduction of new technology, mapping out those involved in, or affected by, its implementation is a useful tool in understanding a wider context. Tesla's AV is part of a greater system, where different actors have a stake in adoption. Activity Theory (AT) provides a tool for understanding goals and motives of stakeholders involved in the activity (Lahlou, in-press). However, there are limitations to AT (i.e. no account for the agency of AVs), and Actor-Network Theory (ANT) addresses these limitations. Additionally, ANT reinforces the importance of the connection between the actors, as Dolwick (2009) reiterates, 'strength comes from associations.' Also, ANT is specifically designed to address science and technological developments (Callon & Latour, 1981; Roberts, 2012; Cressman, 2009), the aim of the following report.

Therefore, a combination of AT and ANT forwards the analysis by identifying a common goal and how different actions contribute to an outcome. Figure 1 maps out the stakeholders in a mobility system to better detect and understand the interests involved.

Fig. 1 - Mobility Stakeholders



The illustration presents the possible alternative forms of mobility. According to their needs and motives, users can choose from a personal vehicle, public transport, and cycling or walking. However, this report focuses on Tesla and the role of a private vehicle, specifically the driver-vehicle relationship. Thus, the complex system of mobility is narrowed to focus on one particular activity that involves three principal actors: the driver ("the user"), motor and technology companies ("the producer") and the government ("the regulator"). Their motives and goals provide a context for further analysis.

In Lahlous's (2011) simplified version of AT, the framework focuses on following a subject through all the small steps that constitute an activity. AT takes note of each action, and each object encountered that helps a subject to achieve a goal. The framework is dynamic, adjusting as conditions change the end goal. The following analysis illustrates the tasks performed during the act of driving (Figure 3) and the goals and motives of the stakeholders (Figure 2).

Fig. 2 - Stakeholders Goals and Motives

The User: Car drivers	**Motive:** Transport choice permits having control, save time, it is convenient and comfortable, independent, gives personal space, signals identity **Goal:** Commute to work
The Producer: Tesla	**Motive:** Accelerate the world's transition to sustainable energy **Goal:** Introduction AVs
The Regulator: Government	**Motive:** Efficient, safe, clean, sustainable transport **Goal:** Regulation, Infrastructure

Fig. 3 - Description: Activity Driving

Activity: Driving	**Goal:** Commute to work	***Current state:* At home**	***Final state:* At work**
Tasks	***Actions***	***Operations***	***Affordances***
Need to use the car to move yourself from A to B			
Define the best route in terms of the activity (efficient, scenic, state of the road, security, etc.)	Check waze/google maps/mobility apps Previous experience and knowledge (overconfidence in choosing the best route)		Driving apps: Identifying best routes Avoiding traffic
Get inside the car and setting to initiate your trip		Find the keys; Take your driver licence; Open the door; Get in the driver seat; Adjusting the seat; Adjusting the mirrors; Fasten the seatbelt; Check hand and foot controls (steering wheel, pedals, handbreak, dashboard, etc.); Turn on the radio, select music; Setting GPS in place	
Start driving and following the route	Pay attention to the road Following directions and rules Interacting with other vehicles	POM (Prepare, Observe, Move); MSM (Mirrors, Signal, Manoeuvre); Press the pedals to move; Press the pedals to stop; Changing gears; Using the indicators; Changing lanes	AV: Reducing stress and workload for driver, Make driving more efficient, Reducing accidents Traditional vehicle: Distributed cognition, Helping identifying tasks, Relationship human-machine
Arriving to the destination	Find a place to park		
Stepping out of the car	Make sure where you are parked	Turn off the engine Unfasten the seatbelt Take your things and go out Close the vehicle	

The Driver

The motives associated with the goal, commuting to work, include having control over the destination and route, time savings, comfort, and the privilege of personal space. Steg (2007) compiled a literature review looking at why a private vehicle often appears more attractive than public transport. The author enlists convenience, flexibility, comfort, speed, independence, reliability, and pleasure as the most important characteristics influencing people's choice to use a private vehicle.

Regarding the activity of driving, Lahlou (in press) describes an activity as a series of tasks and subgoals that together support the final goal. During each task, the subject acts (takes conscious and deliberate steps), or operates (makes automatic subconscious moves). Related to driving, small steps allow the driver to get from the current state (e.g. being home) to the final state (e.g. arriving at work). Given the habitual nature of driving, these tasks likely include automatic actions (or operations) rather than conscious actions. The following outlines some of the tasks necessary to achieve the end goal. First, an initial need or desire to travel arises and the identification of an optimal route (aided by experience or mobility applications) is identified. Next, the driver enters the vehicle and follows a routine of checking and adjusting mirrors, fastening a seat belt, and so on. Then, the driver starts the engine by stepping on the pedals, maneuvering the steering wheel and changing gears. Affordances allow the driver to identify necessary actions, and also signal to other vehicles. Subsequent steps include making stops, going forward, following traffic signs and road regulations. Finally, the vehicle arrives at the desired destination and the driver parks the car, turns off the machine and steps outside.

The Producer

As an integral part of the mobility system, the producer (i.e. Tesla), has the responsibility of designing the vehicle and the interface for the driver. The motive for Tesla, and its interest in AVs comes from the company's desire to, "accelerate the world's transition to sustainable energy" (Tesla, 2016). By developing the hardware and software, and facilitating broad AV adoption, Tesla achieves a goal toward fulfilling its mission. Tesla can assure a smoother transition for the vehicle's user by understanding all the actions and operations the driver currently faces, and putting those needs and habits at the forefront of vehicle design.

The Regulator

The number of driving related fatalities due to human error, health related issues due to pollution, and increased rates of traffic congestion in urban environments are among the U.S. Government's motives to promote AV adoption as part of the Policy Agenda (U.S. Department of Transportation, 2016). The government's role, as a regulatory body, is to make the necessary adjustments to the infrastructure needed for transportation and the integration of AVs (sensors, connectivity, dedicated lanes, etc.). The government is also responsible for setting rules and standards governing AV use and thereby ensuring a safe transition.

By understanding the motives and goals for each actor in the mobility system, Tesla can approach its primary goal, to integrate AVs into everyday life. Furthermore, the description of the act of driving is a useful tool in addressing resistance arising from the interaction between the driver and the vehicle. The obligatory passage point (OPP), which is a facet of ANT, is then established. The OPP is useful in bringing the goals and motives to a convergence point, ensuring sustainable solutions in which all new initiatives have to be formulated and evaluated based on stakeholder's interests (i.e. Figures 1 & 2). Moreover, ANT calls for the description and the development of relational ties within a network, considering non-human entities as actors. ANT is a broad theory (Latour, 1996; Cressman, 2009), and certain concepts apply to the analysis of autonomous technology. These concepts are the obligatory passage point, autonomous vehicles having agency, and the actor-network of autonomous vehicles.

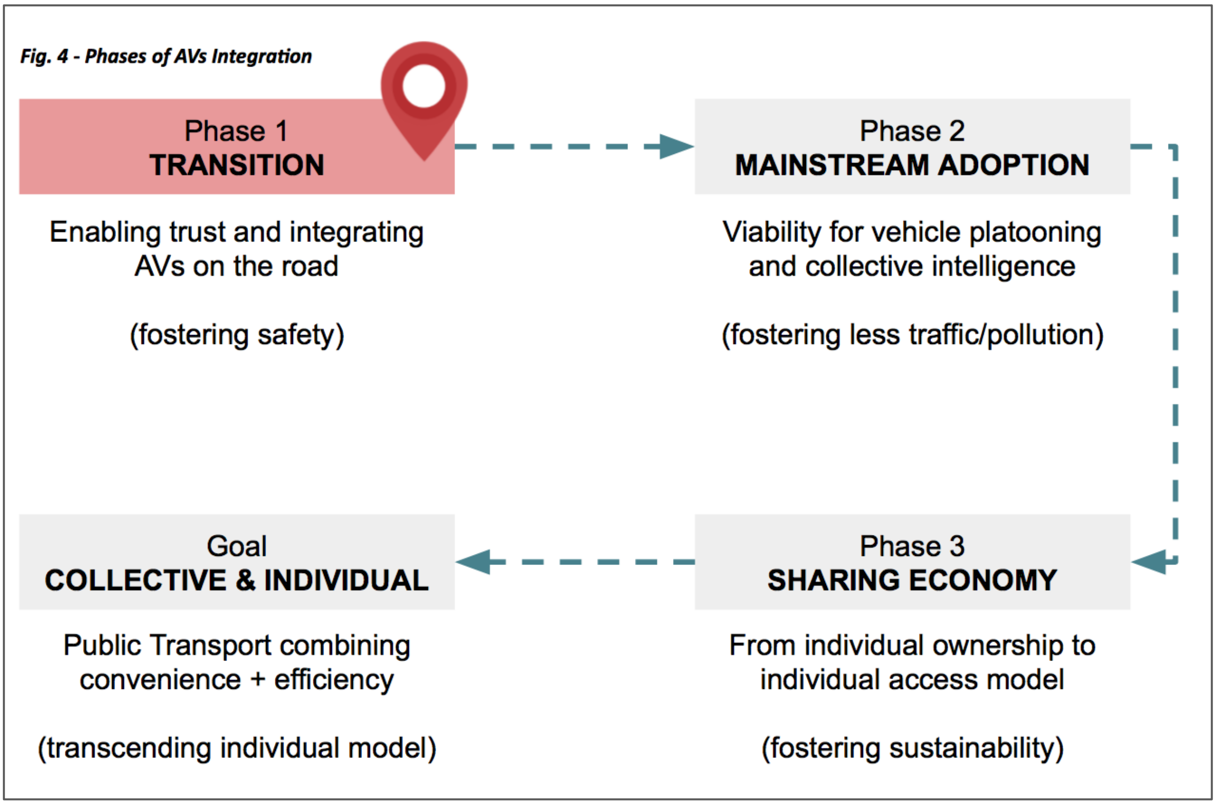
ANT embodies the concept of 'things,' such as AVs, having agency (van Binsbergen, 2005). Therefore, AVs provide a 'backdrop for human action' by creating affordances that suggest, influence and render possible behavior (Latour, 2005). AVs do so by suggesting road alternatives, or making decisions through the calculations and predictions of the trajectories of surrounding objects. Acknowledging the social agency of non-human entities provides a comprehensive approach to understanding AV integration into everyday life (Nimmo, 2011). A purely functional approach would be limited by the technical specifications of the product (AV), it's pricing, placing and promotion (marketings 4 P's). By using ANT, the report situates the driver-vehicle relationship within a broader context and demonstrates how many environmental factors contribute to maintaining the status quo.

Since the invention of the automobile in the early 1900s, human environments have been designed to facilitate the use of the car. In just over a century, governments invested billions of dollars in building roads and highways and formed regulations, rules, and affordances to govern their use (e.g. traffic lights, speed limits, dedicated lanes, insurance requirements, safety regulations, parking lots, etc.) (Glaeser & Kahn, 2004). The infrastructure enables and propagates a "driving culture," fueled by the convenience of the surroundings (Steg, 2007). However, the environmental, economic and social infrastructures traditionally established for conventional vehicles have now become an obstacle to the development and integration of AVs. The current rules and regulations, designed for conventional vehicles, in some sense constrain AV development.

Analysing inter-network connections promotes innovative thinking (Hoholm & Strønen, 2011, Callon, 1986), and allows for the possibility of AVs as an extension of our digital space. The AV not only acts in a physical and social space, but also in a digital space. As Callon explained, "actors may construct a plurality of different and incommensurate worlds" (1986, p.24). Such an observation encourages further research into the digital influence of AVs. The vehicle now offers a platform for connecting to and using other applications. Integrating these spaces may help drive the process of normalization and adoption of AVs. Just as the smartphone transformed daily life, the vehicle offers a range of abilities extending beyond mobility. For instance, an AV can provide a game center, office and sleeping space, and so on; changing the very nature of a vehicle. Expanding the definition of a vehicle presents opportunities for new business models such as ride-hailing in the sharing economy, and the transformation of the automotive insurance industry. In this regard, ANT allows for a more fluid, less static production of knowledge by showing how identities could be (re-)aligned to realize the innovation (Callon, 1986).

3. You are here: Phases of Integration

Once at full potential, AV technology addresses many critical transportation issues (e.g. safety, traffic, pollution). However, the benefits come gradually as the technology is adopted. Mapping opportunities of AV development in a sequential manner enables the identification of priorities during each phase (Figure 4). In reality, all phases are happening simultaneously at different levels (Kabbaj, 2016). But, to foster such a disruptive change, addressing each issue by complexity will help guarantee sustainability.



The report focuses on addressing solutions to overcome the current transition phase, as it shapes the subsequent phases, and future opportunities for Tesla. If the driver is unwilling to give up control and trust the AV, adoption will not occur, regardless of the technology's potential. In this context, the report question is as follows: "What aspects of the driver-vehicle relationship should Tesla consider when introducing a fully autonomous vehicle?" The following section will address recommendations for overcoming public resistance to AV adoption, focusing on the driver-vehicle relationship.

4. Recommendations: Driving the Change

The use of Lahlou's (in-press) Installation Theory helps to understand the role that physical objects, embodied interpretive systems, and social controls play in informing our attitudes, beliefs, and behaviors related to driving. Understanding the critical links between held attitudes, beliefs and behaviors, and the mechanisms behind such observations, allows for intervention to occur and facilitate change.

For simplicity, an installation is analyzed at three distinct levels: the physical layer, embodied layer and social layer (Lahlou, in-press). The physical layer analyses how, "physical objects inform, support and constrain activity" (Lahlou, in-press, p.65). The embodied layer addresses the interpretive structures that inform behavior. Interpretive structures include mental models, experience, skills, knowledge, reflexes, habits and common sense. Finally, the social layer imposes rules, regulations and acceptable ways of behaving, enforced by a community for mutually beneficial purposes.

However, the layers often overlap, and intervention that addresses all three layers can help promote sustainable change. For example, physical affordances may serve to reinforce an embodied behavior. The following analysis takes into account the interaction between the three layers, and ultimately proposes recommendations that address the driver-vehicle relationship, using the Installation Theory framework for meaningful change implementation.

Recommendations are developed under the three layers of Installation Theory:

1. Technological reliability (physical layer): addressing trust
2. Willingness to give up control (embodied layer): agency of driving and bounded rationality
3. Integration of "social space" (social layer): building community

While the research question relates specifically to the driver-vehicle relationship, determined as an initial barrier to AV adoption, installation theory allows for the analysis of a broader context. The report addresses the embodied aspect of driving and uses the social and physical layers of installation theory to address the issues raised and recommend solutions to overcome such embodiment. Ultimately, Tesla must consider broader issues, such as how AVs will interact with conventional vehicles and how infrastructure must adapt to support a new standard of mobility. These questions may be addressed with Installation Theory, but are outside the scope of the following report.

4.1. Technological reliability

My AV & Me: The Importance of Trust

Trust is a vital component in forming relationships, as its presence reduces time spent investigating another person, or agent, and therefore lowers transaction costs (Zak & Knack, 2001). The following analysis explores the importance of anthropomorphism and similarity in building trust. The section seeks to identify physical affordances that promote trust building, and concludes that machine learning should incorporate risk and stylistic preferences, as well as personality and communication style. Humanizing the interaction between the driver and vehicle may help increase feelings of trust and affiliation.

The Hello! Effect: Anthropomorphism and Similarity

Waytz et al. (2014) explore how attributing human characteristics to nonhuman objects, a process referred to anthropomorphism, impacts trust in vehicles. The authors take into account behavioral, psychological and self-reported measures. Participants who drove a named, gendered and voiced vehicle, described it as having more humanlike mental capacities. They reported trusting the vehicle more, being more relaxed during an accident and blamed the vehicle less for an accident caused by another driver. Large and Burnett (2014) also explored the impact of driving a voiced vehicle and similarly concluded that driver's placed more confidence and trust in these vehicles. In fact, a simple greeting served as a source of comfort and sign of amicability (Sirkin et al., 2016). The study applies to AVs, as the driver must surrender personal control of the vehicle and place trust in the technology. The authors stress the importance of considering psychological factors, such as anthropomorphism when designing the physical appearance of new technology. Doing so may help increase user confidence.

Beyond attributing general human qualities to vehicles, tailoring these qualities to the unique user may enhance the positive impact on trust. Kulesza et al. (2013) review several studies linking verbal mimicry to prosocial behavior. The researchers find that people respond to virtual agents similar to other humans, and that a similar communication style increases interpersonal trust, controlling for experience. Overall, people tend to evaluate and trust agents who display similar qualities more favorably. Likewise, Verberne et al. (2015) found that perceived similarity positively correlates with trust and liking. People trusted a similar agent more than a dissimilar agent, and verbal mimicry increased trust in a GPS route planner.

Drivers also differ in their preferences for risky behavior. For example, Rhodes and Pivik (2011) studied age and gender differences in risky driving. The researchers found that male drivers reported that they more often engage in driving that can be classified as "risky," as compared to female drivers. Therefore, making sure an AV takes into account the user's risk tolerance, which potentially varies situationally, may increase confidence and feelings of similarity.

Machine learning refers to the idea that machines can adjust their behavior without being explicitly programmed. Tesla systems should not only integrate machine learning into systems tracking and responding to user's risk and driving preferences but also increase overall trust in the vehicle by adapting to a user's personality and communication style. In this way, the AV may be perceived as a part of the "team."

4.2. Willingness to give up control

I Drive, Therefore I Am: Agency of Driving

Hutchins (1995) proposes that the memory of speed in the cockpit is distributed across processes that are external and internal to the pilot. In other words, cognitive processes are shared across humans and devices. Similarly, the act of driving is cognitively distributed in a driver-vehicle system where both the driver and the vehicle have agency, as previously noted. A driver's tasks often include defining a route, steering the wheel, maintaining lane position, detecting hazards, and changing gears. The driver's tasks rely on vehicle execution and input such as GPS assistance, automatic gear change, sensors for detecting hazards, speed and rotation control, emergency braking, and physical affordances (e.g. rear view mirrors, signaling to other vehicles).

When considering an AV, the distributed cognition system changes. The vehicle controls the driving activity, even the interactions with other vehicles (Healey, 2013). Many embodied elements of driving exist, so motivating people to give up their agency and leaving the vehicle in control, may be one of the biggest challenges Tesla faces. One way to address this issue is to give back, or transform, the power-control relationship between the user and the vehicle. For example, the AV can respond to the commands of the user to begin a journey, accept route suggestions, prompt choices impacting the riding environment (e.g. music and temperature), and so on. In this way, the user maintains elements of control, although the nature of the relationship has changed. Furthermore, the user acquires time previously dedicated to the act of driving. Returning time to the user can be framed as returning power and control, as the user is no longer required to attend to the act of driving.

Removing driving affordances and enhancing travel environment

The steering wheel is no longer a necessary element in the goal-directed behavior, so a lack of presence may help decrease the embodied reflexive responses triggered. In conventional vehicles, the steering wheel is central to the act of driving and drivers are told to, "keep two hands on the wheel at all times." Removing the steering wheel addresses the association between a visible cue and the subsequent habitual actions performed. In an AV, the steering wheel prompts the performance of behavior that is no longer necessary to achieve the desired outcome.

However, removing an affordance that triggers an embodied element of driving may cause discomfort and unease among users who have come to associate a car with control, power and the ability to manipulate an outcome. Tesla may encounter resistance to removing the steering wheel and during the transition phase, essentially disembodying the act of driving, Tesla can introduce a retractable steering wheel that folds into the dashboard. In this way, users are assured that they still have ultimate control of the vehicle, but can begin to disassociate the action of driving with the end goal of mobility. Such disassociation can help to break habitual and reflexive responses, changing the overall nature of vehicle and driver relations. Christian Mueller, an expert in systems integration at IHS Automotive, recently stated, "During the transition to full autonomy, vehicles will feature steering wheels to enable manual control and ensure safety. However, they may be either retractable and inflatable device that fold into the dashboard when not in use (Weber, 2016, November 2)." Other affordances warranting removal are the gas and brake pedals, which are designed specifically for the use of a driver and may also trigger embodied responses.

Seating position currently orients towards the front of the vehicle; however, the interior design of an AV can focus on comfort and functionality without the constraints of conventional vehicles. More interior design flexibility means more safety features to accommodate passengers in seated or reclined positions and facing different directions. Currently, seatbelts and airbags are designed to protect passengers seated in an upright and forward-facing position. These are a few examples of affordances that are no longer necessary or must adjust to support a new vehicle design and functionality.

We are only humans: Bounded rationality

Simon (1978) advocated for building a theory of procedural rationality to complement existing theories of substantive rationality. Simon argued that rational decision making is not sufficient when explaining behavior in circumstances that are complex, dynamic, uncertain and that demand attention. The author also suggests that the field of economics should take a more interdisciplinary approach, communicating with other social sciences, such as psychology. The mixture of economics and psychology has come to be known as behavioral economics, despite the fact that Simon (1978) himself found the term odd since no "non-behavioural" economics exists. Thaler and Sunstein (2009) and Kahneman and Tversky (1974) popularly introduced us to non-rational behaviors, named heuristics and biases.

The present report considers a few heuristics and biases that are highly relevant to the current case. The report aims to provide efficient strategies in overcoming these mental shortcuts, which often help us make decisions quickly, but impede the process of implementing AVs. Ultimately, the recommendations will help Tesla to introduce driverless technology in the on-going transition phase.

I'm better than the machine: The better-than-average effect

The Optimistic Bias addresses people's willingness to take risks based on the perceived trust they place in themselves. People tend to be overly optimistic and confident when assessing their personal risk associated with a variety of events, such as traffic accidents (Dejoy, 1989). Furthermore, Dejoy (1989) also states that unjustified optimism likely results in biased judgments. Kahneman (2011) illustrated this point with his finding that, "90% of drivers believe they are better than average." A recent study by Roy and Liersch (2014), examining the self-enhancement of driving ability, found a similar "better-than-average" effect, with 75% of drivers believing they are above the average driver.

Potentially, AVs have the ability to reduce, or even eliminate human error resulting in car accidents. Nevertheless, given that people are inclined to judge their abilities optimistically, Tesla should promote the convenience and efficiency of AVs, rather than focus solely on the safety argument. Additionally, by encouraging similarity between the driver and the vehicle (e.g. verbal mimicry), the above-average-effect could potentially transfer from driver to vehicle. In effect, the layers are overlapping, and this redundancy helps achieve the desired behavior.

Think about the good times: Availability Heuristic

The Availability Heuristic refers to the process of judging frequency by "the ease which instances come to mind" (Kahneman, 2011). Kahneman refers to research on public perceptions of risks, finding that estimates of causes of death are influenced by media coverage. A classic example being the 9/11 events, resulting in Americans flying significantly less (Bebbington, 2010). A similar case holds true for autonomous vehicles. When assessing the safety of AV technology, people may develop a negative impression due to the memory and media coverage of accidents involving AVs, such as the first self-driving car death on June 30, 2016 (Waters, 2016). Tesla must be aware of the potential negative impact of media exposure on its brand. Tesla cannot control for accidents and the coverage surrounding them, but instead, focus on obtaining a positive media image.

Since the media tends to stress the occurrence of negative events, Tesla may use success-based biases as a tool to obtain a positive and accessible image, essentially overcoming the implications of the availability heuristic. This is especially relevant if it is acknowledge that innovation is a process involving knowledge acquisition, persuasion, decision, implementation and confirmation, and often the "obvious" benefits are slowly realized (Rogers, 1983 p. 7). Additionally, adoption is not linear, but rather a curve led by innovators and early adopters (16%), the majority (68%), and laggards (16%) (Rogers, 1983). Applied to AVs, ensuring the early adopters have a good experience may lead the majority into mainstream adoption, as they serve as "opinion leaders" with an ability to influence others through peer networks.

The Kardashian Effect: Success-based Bias

Success-based biases come from the notion that people are inclined to copy successful people’s seemingly “adaptive” behavior (Mesoudi, 2009). As the exact source of achievement is often difficult to isolate, people tend to copy the behavior of successful individuals indiscriminately, as celebrity endorsements illustrate (Mesoudi, 2009). Agrawal and Kamakura (1995) found that celebrity endorsement positively correlates with future profit. However, the researchers point to the importance of identifying appropriate celebrities for the company, brand, and product. Similarly, Petty et al. (1983) found that under some circumstances, a celebrity's likability is more important than the content of the advertisement in forming consumer attitudes towards a product.

Engaging in well planned and carefully executed celebrity endorsements for AV models may increase positive media exposure and ultimately drive AV adoption. Tesla should select influential individuals who resonate with Tesla's philosophy, and do not endorse conflicting products. There are many non-traditional avenues for celebrity endorsements. For instance, Snapchat provides an intimate glimpse into someone's life, and therefore, AV use might feel and appear more authentic than in a staged interview or traditional advertisement.

4.3. Integration of the "Social Space"

We <3 Tesla: Building Community

Beyond increasing trust between the driver and the vehicle, creating a sense of community among AV adopters is an important mechanism aiding in the integration of AV technology. Social identity refers to the "aspects of an individual's self-image that derive from the social categories to which he perceives himself as belonging" (Tajfel & Turner, 1979, p. 40). Creating an exclusive community for Tesla owners to identify as a part of, creates in-group favoritism for members and may also make others eager to join. To establish a strong sense of community, Tesla should view mobility as an experience, not only placing focus on the end goal of reaching a destination. For example, Tesla charging stations offer an opportunity where owners can connect with one another. They can "check in," and share their journey, potentially posting the total distance traveled with their Tesla and the environmental impact they have negated. Tesla (2016) identifies its consumers as "conscientious of the environment" and having a "desire for style". Those characteristics could be made more salient when connecting with a community of likeminded individuals.

5. Take away

In conclusion, this report discusses aspects of the driver-vehicle relationship that Tesla should consider when introducing a fully autonomous vehicle. First, an analysis of the broad mobility system situates Tesla in context. Next, an analysis of the specific act of driving, and the driver-vehicle relationship, emerges as the relevant unit of analysis. From here, the scope of the report narrows to the transition phase, since this phase acts as a catalyzer for the rest of the phases. Finally, through the lens of Installation Theory, and a variety of psychological concepts, the report provides recommendations to overcome the main obstacles identified in the driver-vehicle relationship. Figure 5 provides a synthesis of recommendations.

Fig 5 - Take away recommendations for AVs

"What aspects of the driver-vehicle relationship should Tesla consider when introducing a fully autonomous vehicle?"

Layers	Issues	Recommendations
Technology reliability (Physical layer)	Importance of Trust	Human (anthropomorphism) and rider (similarity) characteristics; Adapting for different risk tolerances; Machine learning.
Willingness to give up control (Embodied layer)	Agency of Driving	Removing driving affordances; Enhancing travel environment.
	Bounded Rationality	Overcoming the above-average-effect (overconfidence bias); Reinforcing a positive brand image (availability heuristic); Building celebrity endorsement (success-based bias).
Integration to "social space" (Social layer)	Building community	Tesla's exclusive community (social identity theory).

6. Limitations

AVs capture the imagination of many due to the promise of a disruptive technology as profound as the 20th-century automobile. A novel technology that has the power to change the future of mobility comes with many implications including regulation, infrastructure, and road integration. As the vision of AVs becomes a reality, many considerations must be made to ensure a smooth transition.

The U.S. National Department of Transportation updated a guideline for local regulation including a 15-point checklist for manufacturers (2016). The Department also invested $4 billion to accelerate the development and adoption of safe vehicle automation through real-world pilot projects. However, issues still exist. For instance, should government impose a law calling for a "utilitarian" algorithm designed to protect society's best interests over the vehicle's user, or should the market decide (Bonnefon et al., 2016)? Should AVs require a label to signal to other drivers their presence? How can the Government foment Autonomous Public Transportation? These are a few matters, of many, that call for further attention.

According to Shervin Pishevar, an early Uber investor, current infrastructure facilitates the use of conventional vehicles and impedes the adoption of AVs (Hook, 2016). Therefore, urban planners must be involved in developing AVs and vice-versa. During the transition phase, dedicated lanes may help facilitate AV adoption and road integration. However, long-term urban planning must account for a complete disruption of the current system.

When envisioning a future with AVs, people often imagine a reality with AVs only, which is likely decades away. As of now, integrating vehicles onto roads dominated by conventional vehicles proves quite challenging. Currently, driving is a social activity, and the road is a social space (LSE & Goodyear, 2016). Beyond interacting with other road occupants (i.e. other drivers, cyclists, pedestrians, etc.), AVs must be able to signal to other vehicles that they have correctly interpreted intentions and will respond accordingly and in a predictable manner. In this context, explicit cues should exist to reveal an AVs intention (e.g. a signaling movement, lighting, sound, etc.) (Sirkin et al, 2016).

Further implications exist, such as insurance policies, driving-related jobs, the economy surrounding transportation (e.g. hotels, road-side businesses, etc.), social equality, and economic factors relating to costs and savings. Additionally, there are technological issues that fall outside of the scope of this report, such as hacking, that must be addressed.

7. Future Research: The long and winding road

Future research should explore the opportunities of the next phases of AV development: mainstream adoption, the sharing economy, and collective & individual mobility. Regarding the mainstream adoption phase, the suggested affordances used to facilitate the transition phase could be removed (AV labeling, retractable steering wheel, etc.). Additionally, the individual ownership model is co-existing with the sharing economy, but the full transition would involve transcending personal vehicles altogether and allowing for individual access to shared vehicles, or collective transportation systems tailored to individual needs. Kabbaj (2016) envisioned a future where transport is both collective & individual, combining the convenience of personal vehicles with the efficiency of public transportation with modular AVs that attach and detach according to travel needs.

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APPENDICES

APPENDIX A - Narrative of a day in the life with(out) AVs

"Imagine you are late for work. You grab a cup of coffee and look for your car keys. You race outside to find your vehicle and step inside. You fasten your seatbelt, turn on your headlights and crank up the heat. You adjust your rearview mirror and start to go over your talking points for your meeting mentally. You place your foot on the brake and with one hand on the steering wheel and the other on the gear shift, you smoothly back onto the street. You shift into drive and roar off. You become consumed thinking about the clients you are about to meet and barely notice a car stalled at the stop sign ahead. You jam on your brakes and sound your horn to signal your frustration. Your phone beeps with an incoming message from your co-worker, but before you have a chance to respond, the car in front of you starts to move. You signal a left-hand turn and continue on your route. Your mind drifts back to your meeting and before you know it you are pulling into your parking spot and stepping from your vehicle.

Now, imagine you are pouring your coffee in your kitchen. Before taking the first sip, you receive a message on your phone from Tesla: "Your vehicle is parked outside and waiting. Please leave within the next five minutes to arrive at your 8 am meeting on time." With your coffee and briefcase in hand, you walk outside, noticing the cold temperature. Luckily, as soon as you step into your vehicle, you are warm and comfortable. You take a seat at your in-vehicle desk and connect your computer to the charging port and wireless network. On your screen appears a suggested route and you click 'start' to begin your journey. You review your talking points for your meeting, and once finished, email your co-workers with an updated agenda containing your last minute edits. The car slows, notifying you that you have reached your destination. As you alight in front of your office, your car says: "Our optimal route saved fifteen minutes. Congratulations! We saved 1.32 gallons of gasoline on our journey this morning." You confidently walk into your office, feeling well prepared for your meeting, and satisfied with your consumption reduction efforts. Your vehicle pulls away from the curb, driving toward the airport to collect your husband, whose flight is due to arrive in an hour."

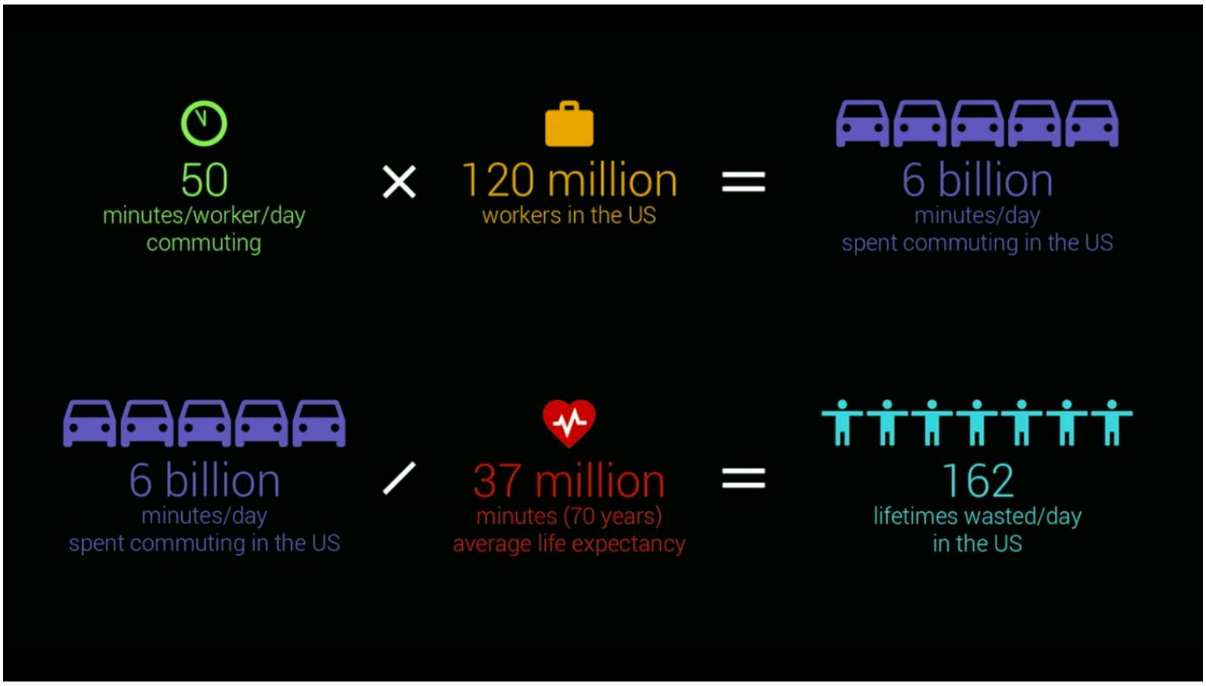
APPENDIX B - AVs currently on the road

Fig. - AVs currently on the road

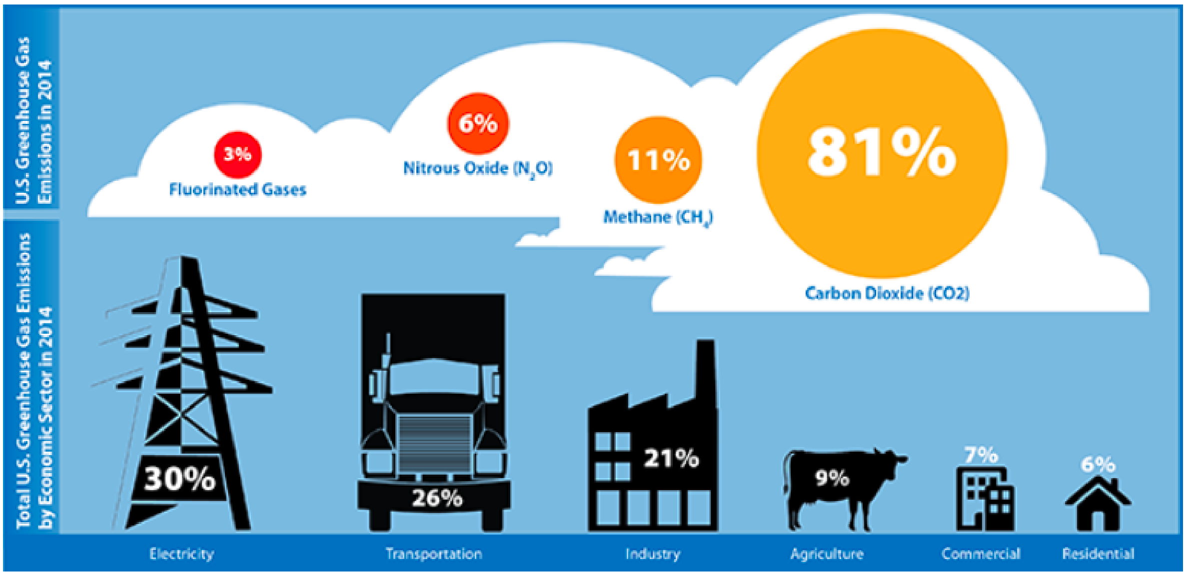
APPENDIX C - Levels of Automation (SAE International, 2014)

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

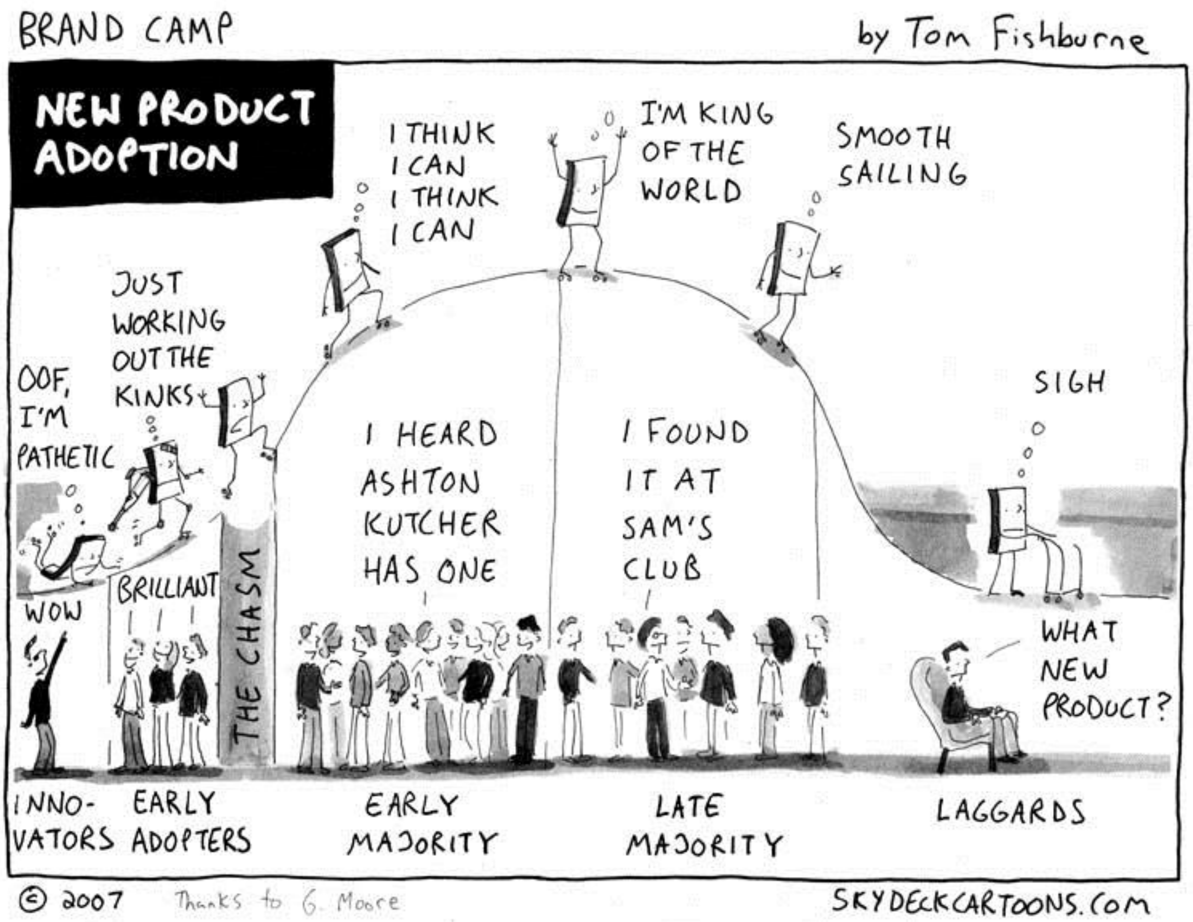
APPENDIX D - Google's (2016) estimated time 'wasted' in traffic



APPENDIX E - U.S. Greenhouse Gas Emissions in 2012 (U.S. Environmental Protection Agency, 2016)



APPENDIX F - New Product Adoption from Rogers Diffusion of Innovations (1983) (Fishburne, 2007)



APPENDIX G - The Tesla Costumer (Tesla, 2016)