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WHO'S ON FIRST: EARLY ADOPTERS OF SELF-DRIVING VEHICLES

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Introduction

Self-driving cars are testing on public roads and may be available for consumers to use within the next few years. *A self-driving vehicle is one in which there is no human driver and refers to the higher levels of vehicle automation (see sidebar). A completely self-driving vehicle does not require a steering wheel, accelerator or brake pedal. All driving functionality is handled through onboard computers, software, maps, and radar and LIDAR sensors. Self-driving cars can be further distinguished as being "connected" or not, indicating whether they can communicate with other vehicles, infrastructure, or other road users.*

The technology is coming but what will it mean for society? Will self-driving cars eliminate traffic fatalities? Will they substantially reduce personal car ownership? Will they increase congestion? Will they reshape urban and suburban development?

Today, the future benefits and costs of self-driving vehicles are uncertain. More information is needed to fully assess how they'll impact drivers, the economy, equity, the environment, and the overarching concern — safety. The first known death of a pedestrian struck by a self-driving car on a public road happened in March 2018. What impact will this fatality have on public acceptance and adoption?

The likely impacts of self-driving vehicles depend on how and when they will be adopted and used. Early adopters may shed light on future adoption patterns. An early adopter is a person who starts using a technology as soon as it becomes available. Research by the Texas A&M Transportation Institute (TTI) determined that early adopters of technology in general, will be early adopters of self-driving vehicles.[1] This premise was extended in a recent study that examined the likelihood that early adopters of mobility technology, like ride-hailing, would also be early adopters of self-driving vehicles.

From Here to Autonomy

Six levels of self-driving capability:

Level 0: No automation.

Level 1: Automated technologies inform and assist driver.

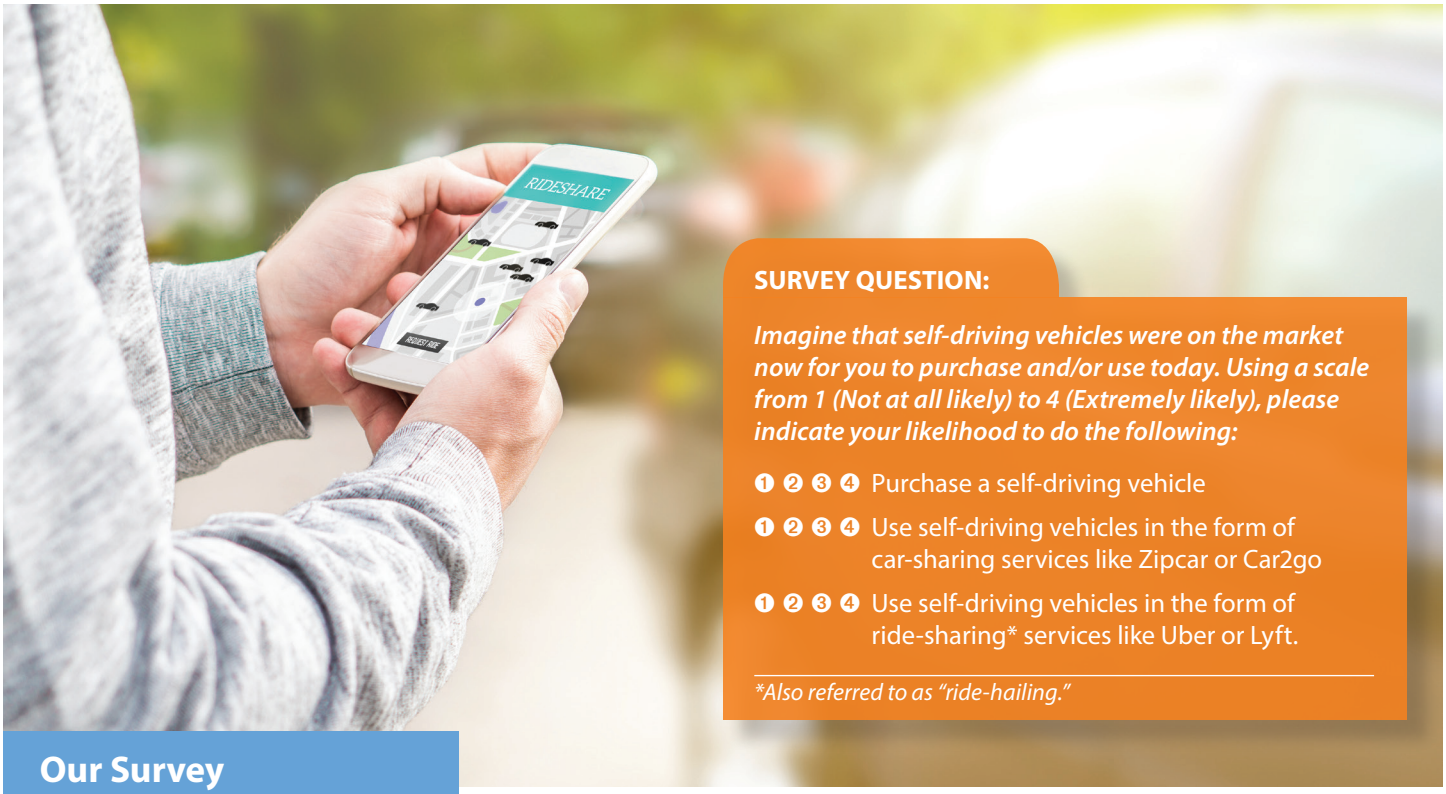
Level 2: Automated technologies detect and respond to potential dangers while driving.

Level 3: Automated technologies can temporarily control driving but human expected to take over at any moment.

Level 4: Vehicle is self-driving in some situations but not all.

Level 5: The car is completely self-driving in every situation.

[1] Zmud, J., I.N. Sener, and J. Wagner. (2016). "Self-Driving Vehicles and Travel Behavior: Demographics of Adoption and Conditions of Usage." *Transportation Research Record*, 2565: 57–64.



SURVEY QUESTION:

Imagine that self-driving vehicles were on the market now for you to purchase and/or use today. Using a scale from 1 (Not at all likely) to 4 (Extremely likely), please indicate your likelihood to do the following:

❶ ❷ ❸ ❹ Purchase a self-driving vehicle

❶ ❷ ❸ ❹ Use self-driving vehicles in the form of car-sharing services like Zipcar or Car2go

❶ ❷ ❸ ❹ Use self-driving vehicles in the form of ride-sharing* services like Uber or Lyft.

**Also referred to as "ride-hailing."*

Our Survey Methodology

TTI conducted an online survey of 3,275 persons in four cities (Boston, Las Vegas, Phoenix, and San Francisco/Silicon Valley), sponsored by Lyft. The survey sampled current ride-hailing users (through Lyft's database) and non-ride-hailing users (from the *ResearchNow* online panel). It took place from December 2017 to January 2018, and used questions that were consistent with TTI surveys conducted in 2015 and 2016. The four cities are those in which tests of self-driving vehicles are taking place on public roads, increasing the likely awareness of self-driving vehicles. A video depicting the technology was also embedded in the online survey to raise knowledge levels and increase answer reliability. A small number of follow-up qualitative interviews were conducted by telephone to probe on surprising or seemingly inconsistent responses.

Evolving from the late 2000s, ride-hailing services rely on smartphone apps to connect paying passengers with drivers who provide rides (for a fee) in their private vehicles. Payment is managed through the app, which stores credit card information. The would-be passenger requests a real-time ride through the mobile application, which then communicates the passenger's location to drivers via GPS. Transportation Network Companies (TNCs) design and operate these online platforms. TNCs have generally found their market niche in urban areas. Complete characterization of TNCs is difficult, though, as the services are continuing to evolve. In recent years, TNCs have launched several services that offer passengers the option of sharing a ride and splitting the cost with others, so-called "pooled" services.

Our study tested and confirmed two hypotheses:

1 ***Current ride-hailing users are more likely to use self-driving vehicles than non-users.***

Intent to use was highest among long-term users of ride-hailing services. They were more likely to use self-driving vehicle technology than non-users by a margin of almost 2 to 1.

2 ***Among ride-hailing users, acceptance and likely usage increases with ride-hailing experience.***

The longer people have used ride-hailing services, the more likely they will use self-driving vehicles.

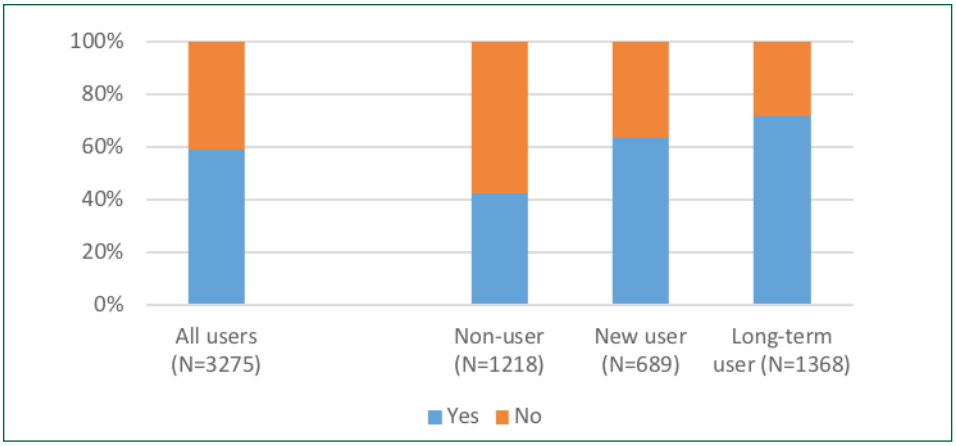


Figure 1: Is a Self-Driving Car in Your Future (by Ride-Hailing Use)

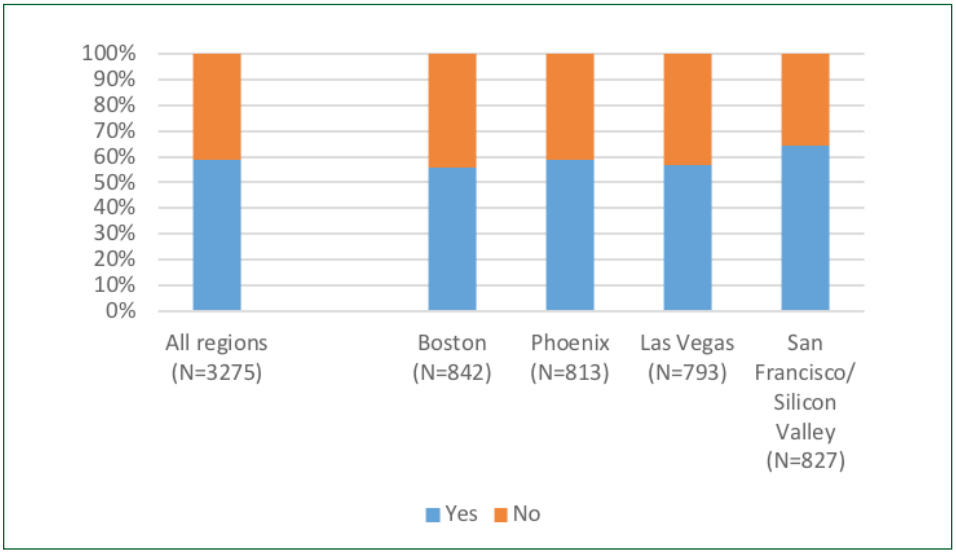


Figure 2: Is a Self-Driving Car in Your Future (by City)

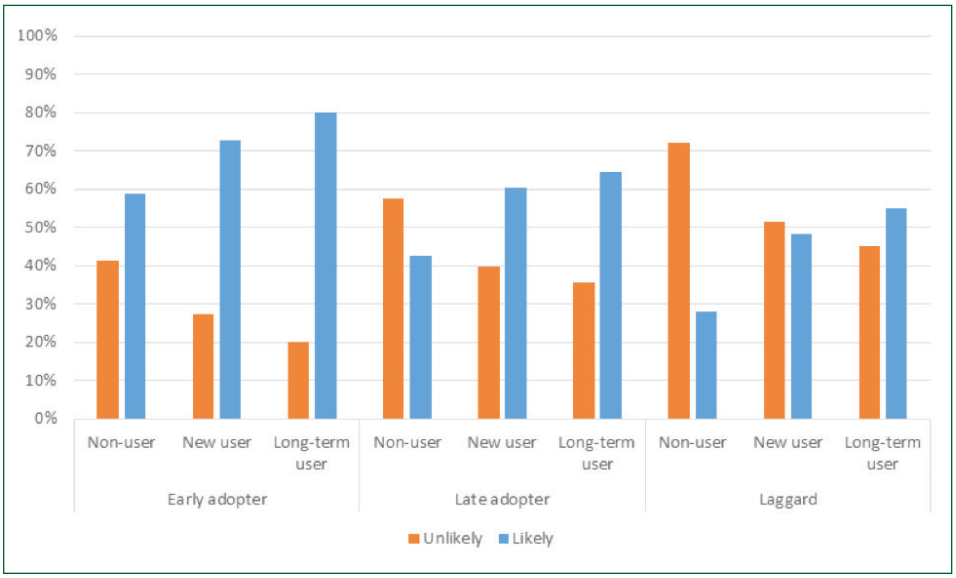


Figure 3: Intent to Use a Self-Driving Vehicle by User Type at Different Technology Adoption Levels

Is a self-driving car in your future?

"Intent to use" reflects technology acceptance, which is a necessary precursor to technology adoption. Overall, almost 60 percent of our survey respondents stated an intent to use some form of self-driving vehicle (see survey question on page 2). Intent to use was exceptionally higher among users of ride-hailing services than among non-users of such services. Acceptance was about 42 percent among non-users, 63 percent among new users, and 71 percent among long-term users of ride-hailing services (see Figure 1).

Intent to use in this survey was higher than in TTI's 2015 survey in Austin, Texas (in which 50 percent indicated an intent to use) and in TTI's 2016 surveys in Dallas, Houston, and Waco (in which intent to use ranged from 53 percent to 56 percent). The greater familiarity that people have with this technology today is one factor for the increased acceptance. Observability and trial ability are characteristics of innovations that influence their adoption. The chances of adoption are greater if consumers can observe a new technology or if they can try it out. Figure 2 presents survey results on intent to use by city.

San Francisco/Silicon Valley residents have the longest history of using ride-hailing services and of observing self-driving vehicles; and this is reflective in the higher percent of respondents who express intent to use (64 percent).

In our survey, we also asked how respondents would classify themselves when it comes to adopting new technology. (See Figure 3.) The results highlighted the increased intent to use a self-driving vehicle with increased levels of technology adoption (in addition to ride-hailing user experience).

Car-sharing refers to a model of car rental where vehicles are rented out through a smartphone app for shorter periods of time (usually on a per-hour basis) and often intended for short trips in urban areas.

In our research, car-sharing was less familiar to respondents than ride-hailing, and among those who were familiar with the concept, perceived as less convenient and more expensive — and thus, a less attractive option.

What type of self-driving car is in your future?

Our survey not only recognized the significance of early adoption of mobility technology, but also took into account that different types of self-driving vehicles matter to people in their future adoption behaviors.

Generally, shared mobility services were preferred to privately owned vehicles (see Figure 4). Our sample was urban and the majority of respondents were current users of ride-hailing services.

One might expect that current non-users of ride-hailing services would lean toward a preference for use of self-driving vehicles as their own private vehicles. However, they expressed almost equal preference for use of self-driving vehicles through ride-hailing services and as privately owned vehicles.

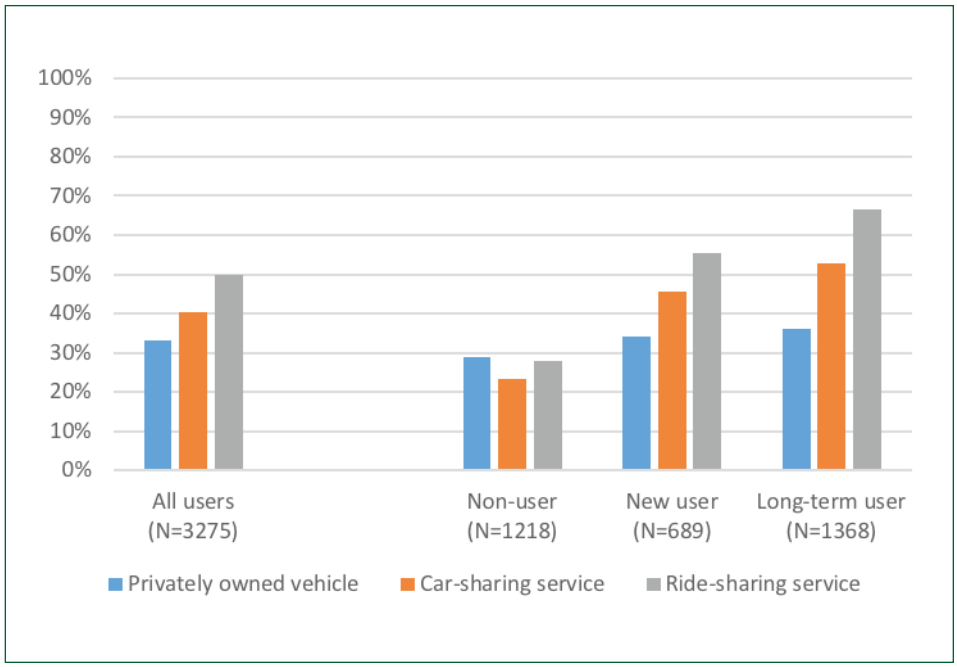


Figure 4: Type of Self-Driving Car Preferred (by User Type)

The strong preference of early adopters for use of the vehicles as a mobility service (rather than privately owned) corroborates others' viewpoints that self-driving vehicles will first be available to consumers as mobility service fleets.[2] Four reasons are typically identified.

1. **Today LIDAR sensors are still too expensive to be used in mass produced self-driving cars.** This cost of technology is considered less of a barrier for fleet vehicles because they will be generating revenue throughout the day to cover the expense, whereas the typical, privately owned vehicle is used for a small fraction of a day.
2. **In addition, automakers are currently marketing vehicles at Level 2 automation.** With people keeping their vehicles on average for about 7 years, and with an average age of vehicles on the road of 11 years, it would take decades to obtain saturation of Level 4 or 5 vehicles.
3. **Early stage deployments will need to be near perfect in operations to engender trust among the public and policy makers.** Testing on controlled roadways so that these technologies are as foolproof as possible is important before their introduction on public roadways. Following this, early self-driving options will likely be geographically-constrained to ensure safe operation. This fits the business model of highly automated mobility fleets, which could quickly begin operating as urban circulator (closed loop) systems as a prelude to less route-constrained, on-demand mobility services.
4. **Level 5 vehicles entail *drive anytime, drive anywhere* operations.** But the fact that many road operators have not implemented or anticipated required "rules of the road" for highly automated vehicles means that they will likely be constrained at early stages of implementation. An owner of a private vehicle may not want to pay a high purchase price for a vehicle that is geographically constrained in its sphere of operations.

[2] The Economist. *Reinventing Wheels.* Special Report. Autonomous Vehicles. Accessed on March 1, 2018.

A lot of research attention has focused on whether the use of ride-hailing services has led to increased congestion and reduced use of public transportation in some urban areas.[3] Because of this, vehicle occupancy rates in future self-driving versions are important. Will there be many single-occupancy trips being made or more high-occupancy trips, which would reduce the number of vehicles needed to move people around?

Our data revealed that people who intend to use the ride-hailing versions of self-driving vehicles will be less likely to use the "pooled" or high-occupancy version of them (see Figure 5). Policy instruments may be necessary to incentivize the use of high-occupancy versions. Generally, price is an important factor, wherein persons with lower household incomes were most likely to intend to use the pooled versions of self-driving vehicles. But there was definitely a difference by city. Residents of Boston were the most likely to use pooled services (closely followed by residents of San Francisco), whereas residents of Phoenix were the least likely. Follow-up interview findings indicated that such preferences were driven by the differing land uses in the cities. For example, people in San Francisco were much more focused on potential congestion impacts.

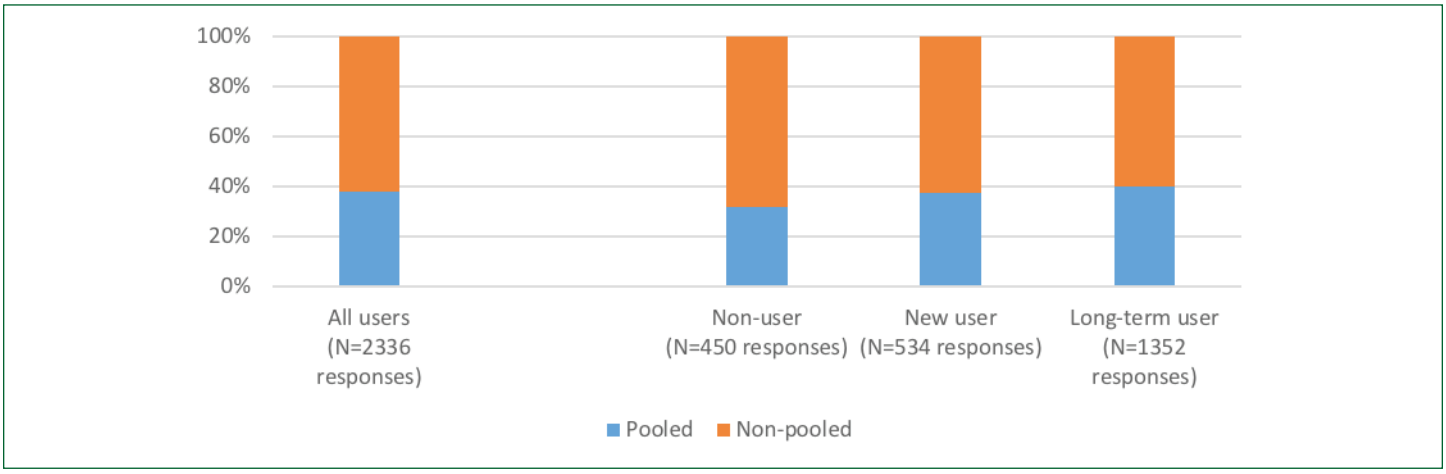
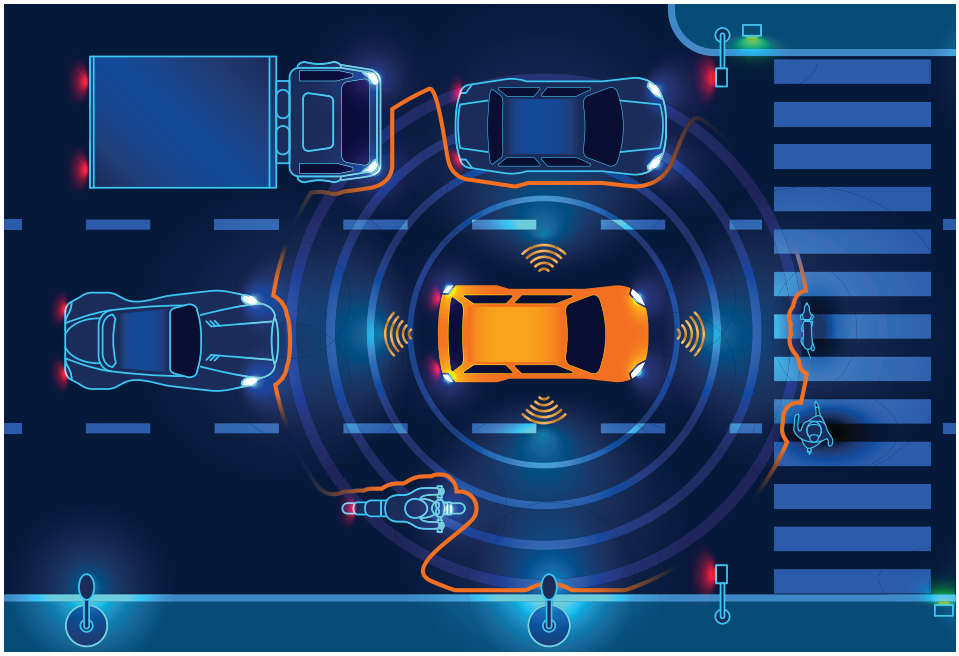


Figure 5: What Type of Self-Driving Car Is in Your Future: Pooled or Non-Pooled?

[3] Hughes-Cromwick, E. (2018). "Do Ride Hailing Platforms Increase Congestion?" Weekly Briefing, Energy Institute, University of Michigan. Accessed on March 13, 2018. http://energy.umich.edu/sites/default/files/umei_weekly_02_20_18_do_ride_hailing_platforms_increase_congestion.pdf

Perceived benefits and concerns about self-driving vehicles

- **Safety concerns and lack of trust** are barriers to owning or using self-driving vehicles.
- **Owning a self-driving vehicle is perceived as more expensive** than using one as a car-sharing or ride-hailing service.
- **Testing before owning** via car-sharing or ride-hailing is an important incentive.
- **The capability to be productive while driving is more important** to ownership than to using via a mobility service.
- **Privacy and cyber-security concerns** are associated with the use of self-driving ride-hailing fleets.



What are perceived benefits and concerns about self-driving vehicles?

People differentiated benefits and concerns among the different types of self-driving vehicles, which definitely influences their intent to use. Tables 1 and 2 present this information and indicate significant differences in how consumers perceive these self-driving options. Research that does not distinguish the different types would not be able to parse out these important differences.

Table 1: Top Ranked Reasons for Intending to Use Different Types of Self-Driving Vehicles

Rank	Privately Owned Vehicles	Car-Sharing Fleets	Ride-Hailing Fleets
1	Relieves stress of driving	Costs will be lower than owning	Ride-sharing convenient for me
2	Trust technology will be tested	Want to test before owning	Costs will be lower than owning
3	Will be productive while driving	Relieves stress of driving	Want to test before owning
4	Safer than human drivers	Trust technology will be tested	Will be productive while driving
5	Lower insurance costs	Will be productive while driving	Relieves stress of driving

Table 2: Top Ranked Reasons for Not Intending to Use Different Types of Self-Driving Vehicles

Rank	Privately Owned Vehicles	Car-Sharing Fleets	Ride-Hailing Fleets
1	Vehicles' ability to react safely	Lack of information	Privacy — my trips will be tracked
2	Cost (purchase)	Don't trust technology	Vehicle may be hacked
3	No need to own car	Lack of control in crash situation	Vehicle's ability to react safely
4	Like to drive	Vehicle's ability to react safely	Don't trust the technology
5	Cost (maintenance and repair)	Safety of vehicle I do not own	Lack of information

What are the influential factors of intent to use self-driving vehicles?

In prior studies, we have found that attitudinal variables were more significantly associated with acceptance and likely use of self-driving vehicles than a variable like age. It didn't matter much if you were a millennial or a baby-boomer. What mattered were other variables like attitudes toward technology or perceived safety.

In our current study, we estimated three distinct models to examine the significant factors influencing the intent to use self-driving vehicles as a privately owned vehicle, a car-sharing service or a ride-hailing service. Several factors were found to be influential, and the results highlighted both similarities and differences in intent to use self-driving vehicles across different types of vehicles.

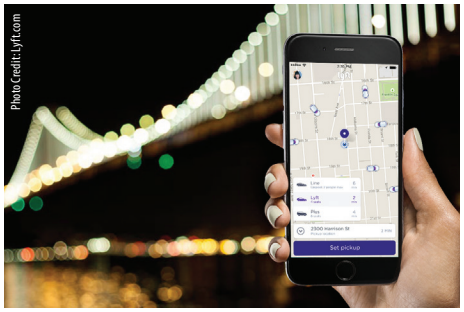
Table 3: Significant Factors on Intent to Use Self-Driving Cars

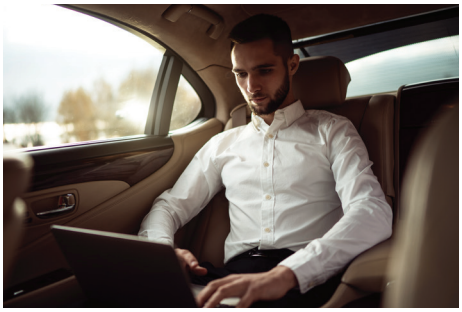
Variables / Self-Driving Vehicle Type	Privately owned vehicle	Car-sharing service	Ride-sharing service
Ride-hailing experience	■	■	■
Age	■	■	■
Unable to drive (medically)	■	■	■
High income (>= 100K)	■	■	■
No-vehicle household	■	■	■
Neighborhood density	■	■	■
Boston	■	■	■
Las Vegas	■	■	■
Phoenix	■	■	■
San Francisco/Silicon Valley	■	■	■
Car-share membership	■	■	■
Frequent internet shopping	■	■	■
Data privacy — no concern	■	■	■
Data privacy — very concerned	■	■	■
Late/last to adopt technology	■	■	■
Self-driving vehicles — fun	■	■	■
Self-driving vehicles — not safe	■	■	■

■ = positive impact; ■ = negative impact; ■ =no impact.

Safety concerns and lack of trust are barriers to owning or using self-driving vehicles.

Photo Credit: theverge.com/ Sean O'Kane





The three reasons our findings are important.

1 ***The size of the ride-hailing market in a city is a good estimate of the likely size of the early future self-driving market.***

2 ***Characteristics of rideshare users define characteristics of early users of self-driving vehicle.***

3 ***Their travel patterns inform early application areas.***

Why is all of this important?

Our study found that current users of ride-hailing services will be early adopters of self-driving vehicles.

Early adopters are most likely to be:

- Evenly split among males and females.
- Young adults (18-34).
- Without children.
- In the middle-income class.
- Owners of zero or one household vehicle.
- Persons with privacy concerns but for whom such concerns do not influence their likelihood of using self-driving vehicles.
- Currently very aware of self-driving vehicles.

Conclusions

The advent of automated vehicles could be transformative to the existing transportation system. However, the ways in which changes could happen are uncertain. Because these vehicles are not yet present in the traffic streams, with the exception of a few test vehicles, it is difficult to reliably predict future consumer demand. Studies are needed to build an evidence base for transportation decision making and policy making.

Considering the premise of current ride-hailing users as early adopters of mobility alternatives, this research was aimed at contributing to the current literature of acceptance and likely use of self-driving vehicles and the role of ride hailing in this decision-making process. In particular, this research examined the hypothesis of increased likelihood of acceptance and use of self-driving vehicles among current ride-hailing users compared to non-ride-hailing users. Based on the survey bivariate descriptive results, the overall intent to use was found to be exceptionally higher among users of ride-hailing services than among non-users of such services. Intent to use was highest among long-term users of ride-hailing services, who were more likely to use a self-driving vehicle technology than non-users by a margin of almost 2 to 1. This study also provided an extensive picture of self-driving vehicle intent-to-use behavior and characteristics.

For more information, contact:

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You may also refer to the full final report, **Examining Future Automated Vehicle Usage: A Focus on the Role of Ridehailing,** *posted at http://tti.tamu.edu/documents/TTI-2018-2.pdf*