DEEPER UNDERSTANDING OF AMERICANS’ AUTONOMOUS VEHICLE
PREFERENCES: QUESTIONS ON LONG-DISTANCE TRAVEL, RIDE-SHARING,
PRIVACY, & CRASH ETHICS

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ABSTRACT

Rapid advances in technologies has accelerated the timeline for public use of fully-automated and
communications-connected vehicles. Public opinion on self-driving of autonomous vehicles (AVs)
is evolving rapidly, and many behavioral questions have not yet been addressed. This study
emphasizes AV mode choices, including Americans’ willingness to pay (WTP) to ride with a
stranger in a shared AV fleet vehicle on various trip types and the long-distance travel impacts of
AVs. 2,588 complete responses to a stated-preference survey with 70 questions provides insight
in the realms of privacy and crash ethics, safety and ride-sharing, long-distance travel and current
preferences of AVs. While the starting sample data were relatively demographically unbiased,
Texans were purposefully over-sampled, and all statistics adjusted/corrected (via sample weights)
to match US demographics on gender, education, income and age.

Results suggest that Americans are willing to pay $2073 to own AVs over conventional vehicles
and an additional $1078 to maintain/include a manual driving option. Ride-sharing will be popular
at 75¢ per mile, under most scenarios, and Americans are willing to pay $1 on average to
anonymize their trip end in many cases, and are willing to let those 16 years of age and older have
unsupervised access to AVs (both privately owned and shared). Nearly 50% of long-distance travel
appears captured by AVs and SAVs in the future, at least for one-way trip distances up to 500
miles.

MOTIVATION

Public opinions regarding vehicle automation and fully automated, or autonomous, vehicles (AVs)
is evolving rapidly. Past studies suggest that AVs, once a distant reality, are becoming more
acceptable over time, and may be a real mode option in the relatively near future (see, e.g., Vujanic
reported that around half of Americans were concerned about riding in an AV, even though they
admitted to the technology’s many benefits, and this view was supported by respondents to
suggests that respondents believed conventional vehicles are still safer than AVs – at least for the
time-being. Schoettle and Sivak’s (2016) second AV survey revealed similar reactions, with more
than 35% of U.S. respondents very concerned about AVs, and partial autonomy less feared. Bansal
and Kockelman (2016), MIT AgeLab (Abraham et al., 2016), Deloitte (2014) and Lee et al. (2017)
have all conclude that younger people are more likely to use AVs, so demographic evolution is
also important to consider, when anticipating the future use and adoption of advanced transport
technologies. Until AVs are widely available in showrooms, at reasonably affordable prices, there
will be regular fluctuations in public perceptions in any country or setting. Thus, regular survey
efforts, and better surveys, with greater nuance, can make valuable contributions to transportation
planning, policymaking, and vehicle production decisions.

With ride-hailing applications maintaining a steady increase in mode shares, especially in dense
settings like San Francisco (SFMTA, 2015), and several studies illuminating the operational
benefits of dynamic ride-sharing (DRS) (see, e.g., Agatz et al., 2010; Bischoff et al., 2016; Fagnant
and Kockelman, 2016; Loeb et al., 2017; Farhan and Chen, 2017), a shift towards shared AVs
(SAVs) with DRS options is expected. However, not detailed studies on DRS have yet been
conducted. Bansal and Kockelman (2016) estimated SAV use for different pricing levels, but do
not delve into ride-sharing. Quarles and Kockelman (2018) have recent, unpublished results that
suggest about XX% of Americans are willing to share rides with strangers by paying about 40
percent less (e.g., 60 ct/mile rather than $1 per mile of SAV use).

Privacy and data security are another relevant topic, with one survey suggesting that privacy is
Americans’ top concern when choosing to not use AVs (Schoettle and Sivak, 2014). Existing work
in this area lacks many details: e.g., what are people willing to pay for privacy-enforcing measures?
Related to this, automation can pose ethical dilemmas. Bonnefon et al. (2016) and Goodall (2017)
believe that public opinion must be considered in crash-response programming and the like.
Jenkins (2016) and Lin (2017) have described several possible outcomes of an inevitable crash
scenario. And Fleetwood (2017) censured algorithms that teach AVs to choose targets by force,
arguing that they should not be readily allowed for public use. However, the public perception of
what is most ethical in crash response contexts, and other situations, like who is to blame for a
computer’s decision or criteria to pass to be allowed to use SAVs, is yet to be determined. This
survey adds new questions and public opinions to that discussion.

Finally, the long-distance (LD) travel implications of AVs are an important consideration.
LaMondia et al. (2016) introduced AVs as new mode for LD trips originating in Michigan. Bansal
and Kockelman (2016, 2017) suggested that LD-trip frequency may well double, and Perrine et al.
(2017) are predicting major losses in U.S. airline revenues, long term, once AVs are widely
available. However, many details are missing, especially questions that probe actual Americans
on these topics.

This paper addresses many such investigative gaps. A description of the survey design and data
processing methods is presented next, followed by summary statistics, results discussion, and
various conclusions.

SURVEY DESIGN & DATA PROCESSING

The survey consists of 70 questions, tackling various aspects of AV and SAV use, including ride-
sharing preferences, privacy and security concerns, ethical implications of crash response
algorithms, long-distance travel shifts, and future travel choices, with each subject section having
about 5 to 8 questions.

The section on current AV perceptions included questions on impressions of and WTP for AVs,
SAV use, and DRS with strangers. Questions regarding an acceptable age for children/young
people to travel individually or in a group were also asked, along with questions regarding opportunities for serving persons with disabilities. AA slider response was used to obtain continuous responses on WTP, including for DRS with a stranger - by time of day (night vs. daytime) and assuming different time delays. The value of providing one’s location en route (to a close friend or family member, to increase travelers’ sense of security) was also addressed, when sharing an SAV ride with an unknown person.

To assess the ethical implications, three distinct ethical dilemmas were posed to the respondents: two regarding AV crashes with a pedestrian and other cars on the road, and one addressing crash responsibility. Questions on LD travel were based on mode-choice preferences for different types of trips and a respondent’s typical LD trip. A demographic section was included towards the survey’s end, to provide control variables and correct for various sampling biases, to better represent the U.S. population.

**Data Collection**

Survey Sampling International’s (SSI) panel of Americans was used to access respondents from across the United States. Nearly 10,000 Americans were targeted before the required sample attributes were obtained, due to two screening procedures. The first screen blocked respondents from accessing the survey in its entirety if they failed to answer two initial basic questions regarding AVs and SAVs, after relevant information was provided. The second level of screening was done by removing respondents who took less than 15 minutes to complete the survey, since a low response time was deemed unrealistic for anyone going through this 70-question long survey. Both screens helped ensure respondents were intellectually engaged, and paying attention.

Most questions contained a text input option as “Other: _____” for respondents to elaborate, and expand response options. These inputs were manually mapped to an existing option or to a new option, as appropriate. After screening respondents and remapping responses, usable sample size was n = 2,588 respondents, from across the United States, with purposeful oversampling (n = 1258) of Texans, due to the research sponsor’s (the Texas Department of Transportation’s) strong interest in understanding Texans’ preferences. Both sets of responses are given below, after a discussion on sample weighting or expansion.

**Population Weighting**

The 2,588 complete responses were associated with household and person-level weights to ensure that all reported statistics and regression analyses reflect the broader population of interest. The U.S. Census Bureau’s Public Use Microdata Sample (PUMS) for years 2011-2015 provided national and state percentages across various classifications: location (Texas vs. U.S.), age, gender, educational attainment and marital status. Certain demographics were under-represented (e.g., males who had not finished high school) and some others were over-represented (e.g., gender ratio was 47/53 rather than 49/51, 24% of the sample were people 65 years or older rather than 18%), resulting in slightly higher weights. MATLAB code performed iterative proportional fitting over all the combinations of dimensions, ending once categorical percentages fell within 0.001% of the population percentages. All of the following results reflect these adjustments to raw sample statistics.

**RESULTS**

**Current AV Perceptions**

As noted above, the survey’s first section gauged perceptions of AVs. Table 1 summarizes the public’s opinion on driving preferences, benefits offered with AV use, concerns in using them, and considerations at play in owning an AV. In general, Texans’ responses do not differ by much, in any survey section, but there are some questions in which notable differences emerge. For example, 36.4% Americans enjoy driving conventional vehicles and do not plan on using AVs in the future, while just 26.7% of Texans give that response. 31.8% Texans (vs. 29.4% of Americans
overall) want to keep the AV option open for their travel, even though they enjoy driving, while 15.0% of Texans (vs. 11.6% of Americans) expect to prefer AV use to driving.

The great majority (92.9% Americans and 90.5% of Texans) believe that safety is a major AV benefit, yet over 60% are concerned that AVs may not be safe enough, with faulty software being a top concern. The mixing of AVs and conventional vehicles on public roadway is also an important concern. Top factors favoring AV ownership, instead of U.S. households relying more on SAVs, are the ability to store items in one’s own vehicle and keeping one’s own vehicle relatively clean or free of other’s germs, while enjoying greater privacy and flexibility in their AV use decisions. It was unusual to find an AV’s self-parking ability to be chosen by less than 2% of Americans as a major benefit. Proxy information about individuals with a disability was assessed, and 59.2% of Americans and 60.3% of Texans acknowledged that they knew at least one person among their immediate family, relatives, friends or neighbors, who was disabled and would benefit from the use of SAVs.

### TABLE 1 Driving Preferences and Factors Affecting AV Ownership

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current driving preferences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoys driving and does not plan to use AVs</td>
<td>36.4%</td>
<td>26.7%</td>
<td>Does not like driving and will prefer AV use</td>
<td>11.6%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Enjoys driving but will prefer some AV use</td>
<td>29.4%</td>
<td>31.8%</td>
<td>Prefers only non-motorized modes of travel</td>
<td>2.9%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Prefers some driving as well as some AV use</td>
<td>17.5%</td>
<td>14.0%</td>
<td>Does not like driving but does not plan to use AVs</td>
<td>0.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td><strong>Expected major benefits of AVs &amp; SAVs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety improvement offered by AVs</td>
<td>92.9%</td>
<td>90.5%</td>
<td>Reliability</td>
<td>1.7%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Congestion relief</td>
<td>2.8%</td>
<td>1.9%</td>
<td>Self-parking</td>
<td>1.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Convenience of travel</td>
<td>2.6%</td>
<td>2.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Expected major concerns of AVs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety is still questionable</td>
<td>66.5%</td>
<td>62.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faulty software in AVs</td>
<td>75.6%</td>
<td>71.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confusion among human drivers and AVs on the streets</td>
<td>49.9%</td>
<td>51.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Privacy breaches inside AVs</td>
<td>16.9%</td>
<td>19.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others tracking one’s home or work location is easier with AVs</td>
<td>30.3%</td>
<td>39.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Factors causing one to own AVs instead of sharing SAVs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking space availability</td>
<td>6.1%</td>
<td>7.4%</td>
<td>Privacy benefits of owning an AV</td>
<td>19.9%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Relative cost of AVs over conventional cars</td>
<td>15.2%</td>
<td>11.0%</td>
<td>Hygiene concerns about SAVs that are not clean due to previous use and possible presence of germs</td>
<td>8.2%</td>
<td>11.6%</td>
</tr>
<tr>
<td>Availability of children’s car seats in one’s own AV</td>
<td>13.3%</td>
<td>14.7%</td>
<td>Security and safety</td>
<td>0.4%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Ability to leave small items behind in one’s own AV</td>
<td>21.4%</td>
<td>22.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage space for large items</td>
<td>15.6%</td>
<td>15.4%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Americans appear WTP, on average, $2073 more to own an AV as compared to a conventional vehicle, plus another $1078 if that new AV includes a human-driving mode option.

**Ride-Hailing and SAV Use**

The survey’s second section emphasizes ride-hailing applications and SAV use, including respondents’ willingness to allow children to use AVs. Responses, shown in Table 2, suggest that only 32.5% of Americans (and 33.3% of Texans) have personal ride-hailing experience. Among these ride-hailing users, only 27.3% (across the U.S., and 14.7% from Texas) have shared their rides with strangers.

Texans appear to believe that children should be at least 17 years to use privately owned (household) AVs, while the average American appears comfortable with a 16-year-old threshold. However, 62.2% of Americans were against the idea of sending their own children, at any age, in an SAV, without an adult escort. Texans were slightly more comfortable in such private-AV-use behavior, with an acceptance rate of 45.7%.

**TABLE 2 Americans’ Perspective on Ride-Hailing and SAV Use**

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age appropriate for RIDE-HAILING services</td>
<td>Age appropriate for children to use parents’ AVs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median age (in years)</td>
<td>16.0</td>
<td>16.0</td>
<td>Median age (in years)</td>
<td>16.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Average age (in years)</td>
<td>16.0</td>
<td>16.3</td>
<td>Average age (in years)</td>
<td>16.4</td>
<td>17.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Avg. Age</th>
<th>Texas</th>
<th>Avg. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it acceptable to allow a group of children use an SAV without adult supervision?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes, if there are all at least XX years old.</td>
<td>26.2%</td>
<td>16.2 yrs</td>
<td>27.9%</td>
<td>16.1 yrs</td>
</tr>
<tr>
<td>Yes, if any one child in the group is at least XX years old.</td>
<td>23.0%</td>
<td>16.8 yrs</td>
<td>30.9%</td>
<td>16.7 yrs</td>
</tr>
<tr>
<td>No, it is not acceptable to send children in SAVs.</td>
<td>62.2%</td>
<td></td>
<td>54.3%</td>
<td></td>
</tr>
</tbody>
</table>

**Ride-Sharing with Strangers and Willingness to Pay (WTP)**

Public opinion on ride-sharing with strangers (while using an SAV) was assessed in detail. First, a hypothetical 5-mile SAV trip was presented and rising travel times (to reflect delay from adding another passenger) were added to this trip. Next, each respondent’s willingness to share the same, hypothetical, 5-mile trip during the night was assessed. Maximum travel delays for sharing trips during the middle of the day and during the night were identified. Any added willingness to use DRS when their location was continuously available/broadcast to a family member (or friend) was also recorded, for both cases of day and nighttime trip-making. In addition to these preferences, the ideal cost of using an SAV in order to willingly let go of a currently owned household vehicle was obtained for different SAV response times (i.e., the time taken between a trip request and the SAV’s arrival at the traveler’s origin). All these results are summarized in Table 3.

As shown in Table 3, only 62.5% Americans and just 54.9% of Texans may be willing to share their ride with strangers when no delay accrues (i.e., no time is added to their 5-mile trip). This willing-to-share-rides pool of respondents reported an average WTP of 74¢ per trip-mile. Interestingly, all scenarios of added travel time returned a similar average. Americans (and Texans) may be more interested in their trip distance than their travel time, once they have opted to share their ride.
### TABLE 3 Ride-Sharing Preferences During Middle of the Day

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to use SAV with strangers, no additional time</td>
<td>22.5%</td>
<td>30.0%</td>
</tr>
<tr>
<td>Yes</td>
<td>22.5%</td>
<td>30.0%</td>
</tr>
<tr>
<td>Maybe</td>
<td>40.0%</td>
<td>24.9%</td>
</tr>
<tr>
<td>No</td>
<td>37.5%</td>
<td>35.1%</td>
</tr>
<tr>
<td>Average WTP (per mile)</td>
<td>$0.74</td>
<td>$0.71</td>
</tr>
</tbody>
</table>

### TABLE 4 Ride-Sharing Preferences at Night

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willing to share a ride with a stranger in an SAV during the night?</td>
<td>4.4%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Yes</td>
<td>4.4%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Maybe, if the stranger has no criminal record</td>
<td>8.0%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Maybe, if the stranger’s identifying information is given ahead of time</td>
<td>4.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>No</td>
<td>83.7%</td>
<td>78.3%</td>
</tr>
<tr>
<td>Average WTP for those willing to share (in $/mile)</td>
<td>$0.87</td>
<td>$0.85</td>
</tr>
</tbody>
</table>

### Maximum trip duration for DRS (with a stranger) in an SAV during middle of day (in minutes)

<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.0</td>
<td>25.0</td>
</tr>
<tr>
<td>32.6</td>
<td>26.0</td>
</tr>
</tbody>
</table>

### Maximum trip duration for a shared ride in an SAV during the night (in minutes)

<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.8</td>
<td>29.0</td>
</tr>
<tr>
<td>35.4</td>
<td>30.0</td>
</tr>
</tbody>
</table>
Maximum trip duration between day and night among those willing to share a ride both in the day and in the night

<table>
<thead>
<tr>
<th></th>
<th>Average during the day (in minutes)</th>
<th>Average during the night (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40.4</td>
<td>34.8</td>
</tr>
<tr>
<td></td>
<td>47.5</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Table 6 summarizes the cost that an SAV must be operated at, for different response times, so that the respondent is comfortable letting go of an existing household vehicle. The American Automobile Association (AAA 2016) estimates that current vehicle ownership and operating costs average 50 to 80 cents per mile, once depreciation of purchase costs are reflected. Those costs can be higher or lower for vehicles driven fewer or more miles per year than the typical U.S. household vehicle. Interestingly, respondents are willing, on average, to pay about that same amount for SAV access – and Texans tend to offer more money than the average American. SAV users can avoid vehicle maintenance and parking costs and hassles, but they cannot guarantee how quickly SAVs will get to them, like they can when walking to their parked vehicle. Actual SAV system experiences will end up impacting everyone’s WTP, and service times may vary a fair bit by location (e.g., urban vs. suburban trip ends). It is an interesting evolution of supply and demand that should one day play out around the world.

TABLE 5 Effects of Ride-sharing Trip Location being Broadcasted

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to use SAV when location is continuously broadcast to family member or friend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During the middle of the day…</td>
<td></td>
<td></td>
<td>During the night…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes, if the location is constantly broadcasted to family</td>
<td>43.0%</td>
<td>50.1%</td>
<td>Yes, if the location is constantly broadcasted to family</td>
<td>21.8%</td>
<td>30.9%</td>
</tr>
<tr>
<td>Yes, even without the location being broadcasted to family</td>
<td>16.4%</td>
<td>18.7%</td>
<td>Yes, even without the location being broadcasted to family</td>
<td>10.4%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Not willing to share a ride with anyone</td>
<td>40.6%</td>
<td>31.2%</td>
<td>Not willing to share a ride with anyone</td>
<td>67.8%</td>
<td>61.7%</td>
</tr>
</tbody>
</table>

WTP for location to be broadcasted to family or friends (to enhance trip safety)

<table>
<thead>
<tr>
<th></th>
<th>U.S.</th>
<th>Texas</th>
<th></th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the middle of the day…</td>
<td></td>
<td></td>
<td>During the night…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8.6%</td>
<td>7.9%</td>
<td>Yes</td>
<td>6.8%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Maybe</td>
<td>18.1%</td>
<td>30.2%</td>
<td>Maybe</td>
<td>8.5%</td>
<td>8.0%</td>
</tr>
<tr>
<td>No</td>
<td>73.2%</td>
<td>61.8%</td>
<td>No</td>
<td>84.7%</td>
<td>77.7%</td>
</tr>
</tbody>
</table>

WTP to share a ride with unknown person during the night if trip locations are continuously broadcast to family or friends

<table>
<thead>
<tr>
<th></th>
<th>Average WTP (in $/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$0.19</td>
</tr>
<tr>
<td></td>
<td>$0.23</td>
</tr>
</tbody>
</table>
**TABLE 6** Cost of SAVs at Different Response Times to Persuade Reduction in Current Vehicle Ownership

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average response time under 1 minute</td>
<td>$0.75</td>
<td>$0.83</td>
<td>Average response time under 10 minutes</td>
<td>$0.52</td>
<td>$0.62</td>
</tr>
<tr>
<td>Average response time under 2 minutes</td>
<td>$0.71</td>
<td>$0.75</td>
<td>Average response time under 30 minutes</td>
<td>$0.38</td>
<td>$0.54</td>
</tr>
<tr>
<td>Average response time under 5 minutes</td>
<td>$0.64</td>
<td>$0.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Privacy Concerns using AVs and SAVs**

Privacy is not on top of respondents’ minds when AV-related concerns are requested at the survey start (Table 1). However, when targeted as a separate topic, more privacy-related concern was observed. Table 7 demonstrates this, with 89% of Americans (and 83% of Texans) to at least some privacy concerns. However, many respondents (39.8% of Americans and 40.6% of Texans) appear unwilling to pay to anonymize their location while using SAVs. Respondents were also asked to rate their levels of comfort when their location data is used for different socially meaningful purposes. Nearly 48% Americans, on average, were comfortable or somewhat comfortable with this data being used for policing activities, managing traffic and for general community surveillance. However, more than half were against targeted advertising use.

**TABLE 7** Privacy Concerns Related to AVs and SAVs and WTP for Privacy

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WTP for anonymizing user location for the entire trip while using an AV or SAV if they opt in</strong></td>
<td></td>
<td></td>
<td>Average (in $/trip)</td>
<td>1.10</td>
<td>1.19</td>
</tr>
<tr>
<td><strong>Comfort level in allowing trip-location data usage...</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...to aid policing activities with a warrant</td>
<td></td>
<td></td>
<td>...for general community surveillance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very uncomfortable</td>
<td>17.7%</td>
<td>15.9%</td>
<td>Very uncomfortable</td>
<td>19.2%</td>
<td>26.1%</td>
</tr>
<tr>
<td>Somewhat uncomfortable</td>
<td>6.2%</td>
<td>9.1%</td>
<td>Somewhat uncomfortable</td>
<td>14.0%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Unsure</td>
<td>22.4%</td>
<td>29.7%</td>
<td>Unsure</td>
<td>30.0%</td>
<td>26.3%</td>
</tr>
<tr>
<td>Somewhat comfortable</td>
<td>27.8%</td>
<td>23.6%</td>
<td>Somewhat comfortable</td>
<td>23.8%</td>
<td>21.6%</td>
</tr>
<tr>
<td>Very comfortable</td>
<td>25.9%</td>
<td>21.7%</td>
<td>Very comfortable</td>
<td>13.0%</td>
<td>10.9%</td>
</tr>
<tr>
<td>...to manage traffic &amp; forecast travel conditions</td>
<td></td>
<td></td>
<td>...to facilitate directed advertising</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very uncomfortable</td>
<td>15.4%</td>
<td>18.8%</td>
<td>Very uncomfortable</td>
<td>42.5%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Somewhat uncomfortable</td>
<td>8.7%</td>
<td>12.6%</td>
<td>Somewhat uncomfortable</td>
<td>17.9%</td>
<td>21.3%</td>
</tr>
<tr>
<td>Unsure</td>
<td>22.4%</td>
<td>24.3%</td>
<td>Unsure</td>
<td>24.0%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Somewhat comfortable</td>
<td>39.0%</td>
<td>30.2%</td>
<td>Somewhat comfortable</td>
<td>11.8%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Very comfortable</td>
<td>14.5%</td>
<td>14.1%</td>
<td>Very comfortable</td>
<td>3.8%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

**Crash Ethics While Using AVs**

Two distinct crash scenarios were presented in the survey, describing an AV crashing into a group of pedestrians in one case and crashing into other cars on the road in another. Respondents picked
from a broad list of options to describe ethical and non-ethical crash outcomes. Table 8 opinions regarding the most ethical outcomes along with the person or business that should be held accountable for such events.

The most popular common believe is that AVs should not change course, once a crash is inevitable, and should crash into the first pedestrian or vehicle that crosses its path. Many others feel strongly that vehicle and pedestrian differences should be ignored while heading into a crash. Presumably, Americans recognize that there is not great solution to most crash situations and no new target (like a heavier vehicle or older adult) should be picked, leaving outcomes more to random chance and relatively similar to what humans may do under such difficult situations, with little response time available. Nevertheless, a strong share of respondents (about 20 percent) would like children to be avoided, when feasible, and more crash-hearty vehicles be selected, to minimize loss of life. More than 60% believe that AV manufacturers should be held responsible for such crashes.

**TABLE 8 Crash Choices and Responsibilities**

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1: AV inevitably crashing into a group of pedestrians</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVs must not change course, no matter what, and must crash into whoever is ahead.</td>
<td>54.2%</td>
<td>47.6%</td>
</tr>
<tr>
<td>The crash must occur without any biases or preferences on age, race and gender of individuals in the group of pedestrians.</td>
<td>24.8%</td>
<td>26.4%</td>
</tr>
<tr>
<td>Children must be avoided under all circumstances.</td>
<td>19.2%</td>
<td>21.1%</td>
</tr>
<tr>
<td>Respondent is unsure if any of the options correctly describes an ethical outcome.</td>
<td>6.8%</td>
<td>9.2%</td>
</tr>
<tr>
<td>AVs must avoid crashing into friends identified in this group.</td>
<td>3.3%</td>
<td>4.2%</td>
</tr>
<tr>
<td>The AV must change into its human-driven operation mode so that the human can instinctively decide.</td>
<td>0.7%</td>
<td>0.3%</td>
</tr>
<tr>
<td>The occupant of the AV must be sacrificed for agreeing to use such a vehicle.</td>
<td>0.3%</td>
<td>0.2%</td>
</tr>
<tr>
<td><strong>Scenario 2: AV inevitable crashing into other vehicles on the road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crash must occur without any biases on vehicle-type, value or insurance.</td>
<td>38.4%</td>
<td>38.9%</td>
</tr>
<tr>
<td>AVs must not change course, no matter what, and must crash into the first vehicle it encounters.</td>
<td>31.8%</td>
<td>31.8%</td>
</tr>
<tr>
<td>The crash must occur such that the overall harm to human-life is minimized (e.g., AVs can crash into bigger vehicles).</td>
<td>19.9%</td>
<td>19.5%</td>
</tr>
<tr>
<td>The crash must occur such that the harm to the AVs occupants is minimized.</td>
<td>11.4%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Respondent is unsure if any of the options correctly describe an ethical outcome.</td>
<td>5.9%</td>
<td>6.5%</td>
</tr>
<tr>
<td>The crash must occur such that cars identified as belonging to a friend must not be damaged.</td>
<td>1.6%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
<th>Response Variable</th>
<th>U.S.</th>
<th>Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who should take responsibility for all damages in an unavoidable crash?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The AV manufacturer should take responsibility.</td>
<td>60.9%</td>
<td>59.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The programmer who built the AV’s algorithm.</td>
<td>23.2%</td>
<td>23.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent does not hold an opinion.</td>
<td>5.0%</td>
<td>4.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Should be decided by insurers.</td>
<td>1.4%</td>
<td>0.4%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Crashes will continue to occur; no one needs to take responsibility. 19.6% 22.2% The courts should decide. 0.6% 1.7%

The individual who owns the AV and knows the risks that entail operating the vehicle should be held responsible for the crash. 0.4% 1.0%

Long-Distance (LD) Travel Choices

Various LD trip-making behaviors were investigated, including frequency of LD trip-making (per month), the longest trip made over the past year, share of LD trips with other persons (e.g., alone versus with friends, family, or colleagues), and mode preferences (across trip purposes and distance bands). Most LD trips occur with family members, and most respondents travel more LD often for personal trips than for business or vacation.

Over 80% of Americans (and Texans) prefer to use their own household vehicle for any non-business trip type under 500 miles. With the introduction of AVs and SAVs, conventional (human-driven) vehicle choice for non-business LD trips under 500 miles drops to 40%. AVs and SAVs enjoy a combined mode preference of 49.6% for business trips between 50 and 500 miles (one-way distance). For distances over 500 miles (one-way), air travel is preferred, for all trip types. Respondents may be expecting that they somehow can better afford air travel in the future, since this mode split is not consistent with current airline use splits. These results will be game-changers when included in LD mode choice analyses in all statewide or national-level models.

CONCLUSIONS

This study builds on gaps in past public AV-perception studies by emphasizing ethics, privacy, nuances of ride-sharing (with strangers in SAVs), long-distance trip shifts, and other facets of future transport. AVs and SAVs are still emerging, and perceptions will evolve as providers deliver more demonstrations and first-hand experiences. In the meantime, policymakers, producers, planners and engineers can all benefit from a sense of what Americans and others expect to do with such technologies.

Americans appear apprehensive about using AVs, with Texans more willing to employ such automation. While Americans anticipate many crash benefits, 67% are concerned about initial safety issues and 76% are concerned about software defects. Trip-making privacy and the ability to leave things behind in a personally-owned AV are key factors in preferring to own, rather than share, an AV.SAV. Average WTP is $2073 (above the cost of a conventional vehicle to own), plus another $1078 to ensure the AV retains a human-driving option. While the average Texan was more WTP for SAV rides (per mile traveled) than the average American, Texans demonstrated somewhat lower WTP for these privately owned AV technologies (at $1948 plus another $949, respectively).

More than 65% of survey respondents have not yet used a ride-hailing service, and only 25% of users had shared their ride (with an unknown traveler) in such vehicles. Most of these people (i.e., prior ride-hailing users) are not comfortable sending their children in a ride-hailing vehicle by themselves. Of those who are willing, the average minimum recommended age is 16 years old, for ride-hailing use. Their responses are similar for children using their parents’ personally-owned AVs in the future, with Texans suggesting (on average) a 17-year-old age threshold. If children are traveling in a group, Americans appear comfortable with the idea if at least one child being almost 17 years old; alternatively, all travelers should be at least 16 years of age (which is the standard minimum driving age in the U.S.).

Ride-sharing preferences among adults were assessed in detail here. For example, the WTP to share rides, with a stranger, is rather stable, at $0.75 per mile for the average American (and just $0.65 per mile for the average Texan), even in the face of added travel times up to 1 hour - at least
for the small share of respondents willing to share rides under such trip-delayed circumstances. Few are willing to use DRS at night, but those who are willing state an average WTP of $0.87 per mile. Most people do not want to share a ride with someone they do not know for more than 30 minutes; but those who are most open to DRS are willing, on average, to ride-share for 45 minutes.. More respondents are willing to share rides at night if their location is made constantly available to a family member or friend, adding another WTP of $0.19 per trip-mile (for this security benefit). While Texans were less WTP for adding automation to a privately held vehicle, they are more WTP for SAV service, per mile traveled (83¢ per mile, on average, vs. 75¢/mile for the average American) when they have to give up one personal vehicle.

Higher levels of concern emerge when privacy is the focus of a survey question, rather than one among many potential issues to be selected by a respondent. Respondents are WTP, on average, more than $1 per trip to anonymize their location information (presumably wanting to obscure their home address most often). They are against targeted advertising (based on their trip coordinates, for example), but comfortable with their data being used for policing, community surveillance, and/or traffic management decisions.

Crash ethics were also investigated, using three targeted questions based on different crash scenarios. The largest single share of Americans (54%) feel that any AV, when having no choice but to crash into one or more pedestrians (or other vehicles, in a related question [with 31% of respondents]) should not change its trajectory (to select a different pedestrian or vehicle to crash into), even if the current trajectory does not minimize overall harm. Avoiding children was also a popular response, but not the top response. AV manufacturers were dominantly (60.9% of respondents) deemed fully responsible for all such crashes. (Of course, some instances, like an inebriated pedestrian running about between two parked cars, would not be ascribed to manufacturers. Either way, the vehicle owner and specific design engineers are not being deemed responsible in such settings.) Americans expect much of their long-distance travel (for trips over 50 miles, one-way) to shift toward AVs and SAVs. For example, nearly 50% of trips between 50 and 500 miles (one-way) are expected to eventually take place in an AV or SAVs, and this is considerably lower than LaMondia et al.’s (2016) prediction of around 55%, on average for these ranges. Airplanes are expected to deliver a major share of business trips (more than currently stated by respondents, perhaps due to some future-optimism bias about affordability).

These results suggest that Americans are not yet very confident about AV use, but expect to develop heavy usage levels. WTP, demand levels, perception and public opinion are helpful to transportation planners and policymakers, technologists and vehicle manufacturers, fleet managers and system operators, as well as airlines, land developers, attorneys, insurers, and the tourism industry. Privacy in trip-making is a concern, with some respondents WTP to anonymize location data. Perceptions of ethics in crash choices should facilitate design of anti-crash algorithms. The aviation sector may wish to adjust its investments and future marketing strategies. Regardless of position, preferences will evolve, as designs are rolled out and experience by more and more people, around the world. Regular survey efforts helps nations and regions, companies and public agencies, better prepare for the coming paradigm shifts, hopefully with equity, environment, and efficiency in mind.. The limitation to keep the survey relatively brief meant that some other new innovative questions were removed before final dissemination. New surveys can inquire about new AV and SAV design, when there will be no need of a driver. Additionally, in the realm of ride-sharing, acceptable waiting times can be assessed instead of forcing a pre-determined waiting time on the respondent for WTP questions.

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REFERENCES


LaMondia, J.J., Fagnant, D.J., Qu, H., Barrett, J. and Kockelman, K. 2016. Shifts in Long-Distance Travel Mode Due to Automated Vehicles: Statewide Mode-Shift Simulation Experiment and Travel Survey Analysis. Transportation Research Record (2566): 1-11.


