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WOULD SELF-DRIVING VEHICLES INCREASE OCCUPANT PRODUCTIVITY?

MICHAEL SIVAK
BRANDON SCHOETTLE

SUSTAINABLE WORLDWIDE TRANSPORTATION
UNIVERSITY OF MICHIGAN

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Michael Sivak
Brandon Schoettle

The University of Michigan
Sustainable Worldwide Transportation
Ann Arbor, Michigan 48109-2150
U.S.A.

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16. Abstract

Currently, in the U.S., the average occupant of a light-duty vehicle spends about an hour a day traveling—time that could potentially be put to more productive use. Indeed, increased productivity is one of the expected benefits of self-driving vehicles.

The data presented in this white paper indicate that for about 62% of Americans, self-driving vehicles currently are not likely to result in an improvement in productivity. This is the case because 23% indicated they would not ride in such vehicles, and 36% would be so apprehensive in such vehicles that they would only watch the road. Furthermore, out of the remaining 41%, around 8% would frequently experience some level of motion sickness—for an additional 3% of occupants.

Of additional concern are nontraditional positions and postures being considered for occupants of self-driving vehicles (positions and postures for which current occupant-protection systems are not optimized), and the behavior in crashes of untethered objects being used for activities in the pursuit of increased productivity.

Consequently, the hoped-for increased productivity in self-driving vehicles would materialize only if the following are achieved: (1) an increased confidence of occupants in self-driving vehicles, which would allow them to be more interested in performing productive tasks while riding in such vehicles; (2) addressing the inherent motion-sickness problem; and (3) solving occupant-protection issues related to nontraditional seating positions and postures, and untethered objects becoming projectiles during crashes (or potentially being placed between the occupants and their airbags).

Also of importance is the fact that current trips in light-duty vehicles average only about 19 minutes—a rather short duration for sustained productive activity or invigorating sleep.

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Introduction

Proponents of self-driving vehicles argue that such vehicles will lead to improved safety, mobility, and productivity. This brief white paper discusses several issues related to the expected increase in productivity of occupants of self-driving vehicles. There are three main concerns: apprehension about riding in self-driving vehicles (and thus apprehension about performing tasks that would increase productivity), motion sickness, and occupant protection.

Current trip patterns

National Household Travel Survey data (FHWA, 2011) provide information about current trip patterns in the U.S. with conventional vehicles. Table 1 shows the average trip length and the average trip duration by trip purpose using privately-owned light-duty vehicles (cars, vans, SUVs, and pickup trucks). These data show that the average trip length is 9.5 miles and the average trip duration is 18.6 minutes.

Table 1
Average person trip length and trip duration using light-duty vehicles (FHWA, 2011).

Trip purpose	Trip length (miles)	Trip duration (minutes)
Home	9.3	19.0
Work	11.9	22.0
School/daycare/religious activity	6.6	14.9
Medical/dental services	10.6	22.6
Shopping/errands	6.3	14.3
Social/recreational	17.2	26.3
Family personal business/obligations	11.6	21.5
Transport someone	7.1	15.3
Meals	7.8	15.7
Other reasons	16.0	26.3
All	*9.5*	*18.6*

Given that the average light-duty vehicle user makes 3.2 trips per day (FHWA, 2011), the average total length of all daily trips is about 30 miles and the average total duration is about 60 minutes. Consequently, the average American can potentially gain an hour of productivity per day in self-driving vehicles.

It is important to note that the average trip is rather short—about 19 minutes. Furthermore, certain types of trips tend to be shorter than others (e.g., trips related to shopping and errands average 14 minutes, while social/recreational trips average 26 minutes). Clearly, longer trips are more conducive to productive engagement.

Apprehension about riding in self-driving vehicles

In a recent public-opinion survey (Schoettle and Sivak, 2014), we asked 3,255 respondents in the U.S., Australia, China, India, Japan, and the U.K. about their views concerning self-driving vehicles. Of relevance to this paper are responses to the question: *"If you were to ride in a completely self-driving vehicle, what do you think you would use the extra time doing instead of driving?"* Table 2 summarizes the responses.

Table 2
Percentage of responses, by country, to the question: "*If you were to ride in a completely self-driving vehicle, what do you think you would use the extra time doing instead of driving?*" (Schoettle and Sivak, 2014).

Response	U.S.	Australia	China	India	Japan	U.K.
I would not ride in a self-driving vehicle	23.0	21.2	3.1	7.8	33.0	23.0
Watch the road even though I would not be driving	35.5	43.4	36.1	30.7	33.2	44.0
Read	10.8	6.5	10.5	10.2	5.6	7.6
Text or talk with friends/family	9.8	7.9	20.8	15.0	7.4	5.5
Sleep	6.8	7.1	10.8	4.7	12.6	7.2
Watch movies/TV	6.0	5.7	11.3	12.3	6.2	4.2
Work	4.8	5.1	5.4	16.3	0.7	4.9
Play games	2.0	2.0	1.3	2.1	1.2	1.9
Other	1.4	1.0	0.7	0.8	0.2	1.7

The following are the most relevant findings from Table 2. First, a substantial percentage of respondents would not ride in a self-driving vehicle (ranging from 3% in China to 33% in Japan, with the U.S. at 23%). Second, even greater percentages of respondents would only watch the road (even though they would not be driving), thus expressing apprehension about riding in such vehicles (ranging from 31% in India to 44% in the U.K., with the U.S. at 36%). By combining these two sets of percentages, we obtain the percentages of persons who would not even attempt to perform another activity in lieu of driving. These combined percentages (see Table 3) range from 39% in China and India to 67% in the U.K., with the U.S. at 59%.

Table 3
Percentages of respondents who would not attempt any activity in lieu of driving, based on responses to the question: "*If you were to ride in a completely self-driving vehicle, what do you think you would use the extra time doing instead of driving?*" (Schoettle and Sivak, 2014).

Response	U.S.	Australia	China	India	Japan	U.K.
I would not ride in a self-driving vehicle	23.0	21.2	3.1	7.8	33.0	23.0
Watch the road even though I would not be driving	35.5	43.4	36.1	30.7	33.2	44.0
Not attempting any activity in lieu of driving (sum of the above two responses)	*58.5*	*64.6*	*39.2*	*38.5*	*66.2*	*67.0*

The above data were based on a survey performed in 2014. However, the general pattern of apprehension about riding in self-driving vehicles has not changed since then, at least not in the U.S. This conclusion is based on the answers to questions regarding concern about riding in completely self-driving vehicles that were included in three annual surveys (Schoettle and Sivak, 2014; 2015; 2016). The percentages of those in the U.S. who said that they would be very concerned about riding in self-driving vehicles were 36% in 2014, 36% in 2015, and 37% in 2016.

Motion sickness in self-driving vehicles

Let us now turn to those people who would be interested in using the time in self-driving vehicles to perform some activities other than watching the road. One problem with attempting these activities is that many of them are known to increase the likelihood of motion sickness.

In a recent report (Sivak and Schoettle, 2015), we calculated the expected frequency and severity of motion sickness in fully self-driving (NHTSA level 4) vehicles in the U.S., Australia, China, India, Japan, and the U.K. These calculations were based on the expected frequencies of activities that individuals would like to do in a fully self-driving vehicle (as reported in Table 2), divided into activities that do or do not increase the frequency and severity of motion sickness. The percentages in the former group were then weighted by the estimated frequencies of their effects on motion sickness. The results are reproduced in Table 4.

Table 4
Percentages of adult passengers in fully self-driving (NHTSA level 4) vehicles who are expected to participate in motion-sickness-related activities, and the resultant percentages of adult passengers expected to experience motion sickness (Sivak and Schoettle, 2015).

Aspect	U.S.	Australia	China	India	Japan	U.K.
Expected to be involved in activities that increase the frequency and severity of motion sickness	37.0	29.7	40.3	52.7	25.9	27.8
Would often, usually, or always experience some level of motion sickness	6-10	4-8	6-10	8-14	4-7	4-7
Would experience moderate or severe motion sickness at some time	6-12	4-10	6-13	8-17	4-8	4-9

The results indicate that, for example, 6% to 10% of American adults riding in fully self-driving vehicles would be expected to often, usually, or always experience some level of motion sickness. Analogously, 6% to 12% of American adults riding in fully self-driving vehicles would be expected to experience moderate or severe motion sickness at some time.

Occupant protection

Two aspects of occupant protection in self-driving vehicles will be briefly discussed: nontraditional occupant positions and postures, and unrestrained objects inside of the vehicle cabin.

Occupant position and posture

Occupant-restraint systems (seatbelts and airbags) in conventional vehicles are designed for optimum performance when the occupant is properly seated in forward-facing seats. However, many designers envision occupants in self-driving vehicles being in a range of nontraditional positions and postures. For example, some of the arrangements being considered resemble living rooms, with occupants in a variety of seating positions and orientations, or even sleeping in a supine posture. Not only would many of these nontraditional positions and postures vary considerably from the optimum for which the restraint systems were designed, but some of them also have the potential to be near-worst-case positions or postures, with g-forces imparted upon occupants during crashes and abrupt stops in ways that are likely to result in more serious injuries than conventional forward-facing seating. For such nontraditional positions and postures, new occupant-restraint solutions would need to be developed to minimize potential consequences of crashes.

Unrestrained objects inside of the vehicle cabin

In a crash, unrestrained objects inside of the vehicle cabin represent a potential danger to all occupants. Consequently, laptops and other large devices would ideally be tethered in self-driving vehicles, if not already fixed or mounted to the interior of the vehicle. This is made more challenging by the situations previously discussed regarding occupant position and posture, especially if front-seat occupants are facing the rear-seat occupants to work or socialize. For example, unrestrained objects flying forward from the rear seats during an abrupt stop or crash that would strike the seat backs in a traditional

vehicle would instead be propelled toward the rear-facing front-seat occupants. Furthermore, rear-facing front-seat occupants would be at risk from their own objects and devices (such as laptops or tablets) that would also be propelled forward toward them during a crash. (An additional problem arises when an object or device is placed between the occupants and their airbags.)

Conclusions

Currently, in the U.S., the average occupant of a light-duty vehicle spends about an hour a day traveling—time that could potentially be put to more productive use. Indeed, increased productivity is one of the expected benefits of self-driving vehicles.

The data presented in this white paper indicate that for about 62% of Americans, self-driving vehicles currently are not likely to result in an improvement in productivity. This is the case because 23% indicated they would not ride in such vehicles, and 36% would be so apprehensive in such vehicles that they would only watch the road. Furthermore, out of the remaining 41%, around 8% would frequently experience some level of motion sickness—for an additional 3% of occupants.

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