



Self-driving Vehicles: Do Their Risks Outweigh Their Benefits?

Peng Liu¹(✉) and Zhigang Xu²

¹ Tianjin University, Tianjin 300072, People's Republic of China
pengliu@tju.edu.cn

² Chang'an University, Xi'an 710064, Shaanxi, People's Republic of China

Abstract. For self-driving vehicles (SDVs), do their benefits to society outweigh their risks? Or their risks outweigh their benefits? Public responses to these questions were not yet surveyed previously. A total of 1032 participants in China were asked this question. Their answers showed that 42.4% thought that the benefits of SDVs are higher than their risks. However, more than 50% participants held other opinions: 20.3% participants believed that the risks of SDVs are higher than their benefits, and 37.3% participants thought that the benefits of SDVs are equal to their risks. Four demographic characteristics were found to affect participants' the benefit-risk perception of SDVs. Those who have heard about SDVs before the survey, male, older (≥ 40), and highly educated tended to perceive higher benefits versus risks. Our findings imply that the public do not show optimism toward SDVs. Effective risk communication is necessary to prevent SDVs from becoming another controversial technology in society.

Keywords: Self-driving vehicle · Benefit-risk perception · Demographic factors

1 Introduction

Mass adoption of autonomous vehicles (AVs) has the great potential to improve traffic and mobility. More than 70% of traffic crashes were thought to be directly or indirectly related to human error [1], which can be largely reduced through widely adopting AVs [2]. It also can increase the mobility for those currently unable to drive. It, with electrification, shared mobility, and connectivity innovations, may have profound environmental benefits in terms of reducing the greenhouse gas emissions and energy use [3–5]. On the other side, it also poses a new set of challenges about safety, security, legal liability, and regulation issues [6, 7]. For example, current road tests [8, 9] did not confirm the safety of AVs over conventional vehicles. AVs usually refer to those vehicles that can run in an automated-driving mode. Self-driving vehicles (SDVs) refer to the AVs with the full automation (the highest automation) and without any human intervention, which are also called fully AVs (FAVs).

A common question for any emerging technology is, do its benefits to society outweigh risks? It would be not a real question to the scientists and engineers working on SDVs in the vehicle industry. If the benefits of SDVs cannot greatly outweigh their risks, there is no reason to design, develop, and deploy them. From the viewpoints of

the lay public, however, they may have different responses to this question. The history of certain controversial technologies such as nuclear power, genetically modified organisms, and nanotechnologies shows that technical experts/scientists and the lay people have conflicting responses to this raised question on the risks versus benefits of these technologies. Understanding public sentiment towards any emerging technology is pivotal because, historically, public perceptions and attitudes have shaped the direction and pace of technology development [10].

This raised question related to the relative risks versus benefits of SDVs is not yet discussed by previous studies, which is the focus in the current study. The risk perception literature on other technologies [11] tells us that public benefit and risk perceptions are driven by many internal and external factors, including cognitive and affective factors, media coverage and information exposure, risk communication and management-related factors. This paper investigates the associations between certain demographic factors (i.e., whether participants have heard about SDVs, gender, age, and education) and the benefit-risk perception.

1.1 Demographic Factors and the Benefit-Risk Perception

Here we simply operationalize familiarity as whether participants have heard about SDVs before the survey or not. The “familiarity hypothesis” in psychology argues that support for an emerging technology will likely grow as awareness of it expands [11–13]. For example, higher level of knowledge was found to positively correlate with more beliefs that benefits of nanotechnologies exceed their risks [11, 13] and with higher benefit perception and lower risk perception [12]. The AV literature does not have any studies on the relationship between familiarity and the benefit-risk perception. But, our previous work [6] observed that those participants who have heard of SDVs before the survey perceived higher benefits and lower perceived risk than those who have not heard of SDVs. In this study, we will examine the relationship between familiarity and the benefit-risk perception.

Gender difference in beliefs and attitudes of risks has been noted in the risk perception literature [14, 15]. Usually, females hold less positive attitudes toward emerging technologies and perceive higher risks from these technologies than males. This difference is weak but systematic. The current literature notices that female participants were less willing to use the AV technology [16] and less willing to pay extra money for adding partial and full automation on their next vehicle [17], but does not touch the gender difference in the benefit-risk perception. In this study, we assume that females perceive lower benefits versus risks than males.

Older adults expect to benefit the most from self-driving in mobility. However, due to their limitations in physical and cognitive functions, using the new technology would be a challenge for them. Younger people are more likely to desire the in-vehicle technologies and options [18], and express more interested in full automation and more willingness to pay for full automation [17, 19]. Another survey [6], however, showed that older participants perceived higher benefits of SDVs than younger participants. In this study, we suspect that age influences people’s benefit-risk perception.

Education may affect people’s perception and preference related to the SDV technology. An international survey [20] showed that higher educated respondents

expressed more concerns about their vehicle transmitting data; however, another survey [6] did not find education affects the surveyed participants’ perceived benefit and perceived risk of SDVs.

2 Methodology

The methodology can be found in our previous work [6]. The data used in this study was extracted from our current large-scale surveys on the general Chinese public’s responses to SDVs in the future. Next we brief the methodological issues related to the current study.

2.1 Participants

An offline survey was conducted in Tianjin (a tier-2 city in China). Participants were approached through direct intercept by trained interviewers while at recreational areas. A total of 1032 participants submitted valid data for further analysis. Among them, 79.4% ($n = 819$) have heard about SDVs before the survey, 47.2% ($n = 487$) were female. Other demographic information is shown in Fig. 1. Our participants were skewed toward younger and highly educated compared to the general Chinese population.

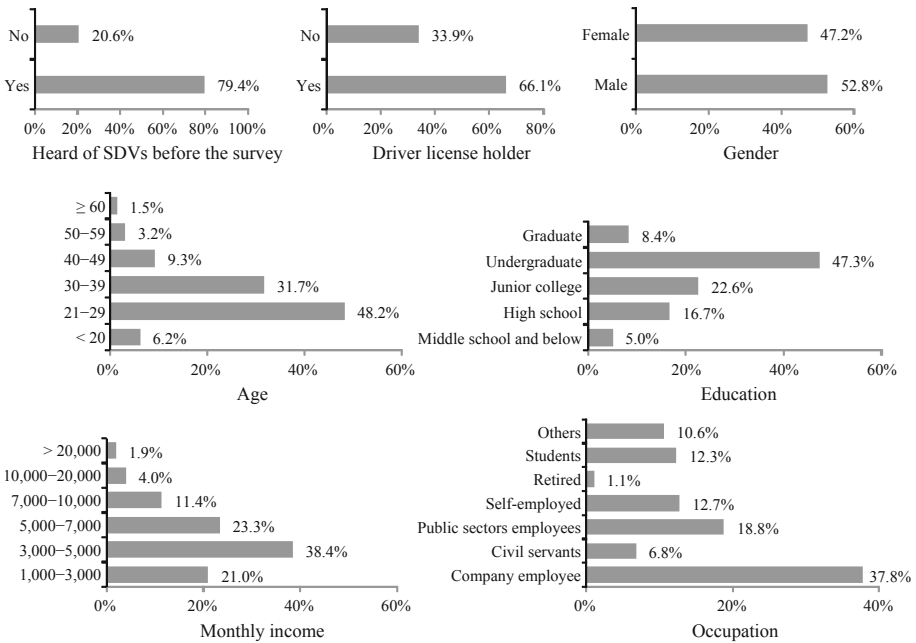


Fig. 1. Demographic information ($N = 1032$).

2.2 Procedure and Measure Design

After participants agreed to participate in the survey, they were instructed to read a short description and graphic scenario of SDVs on the cover page (to reduce response biases when participants were unfamiliar with this technology), respond to a series of items about SDVs, and give their demographic information [6]. The verbal description was as below [20]: “The automated driving system takes over speed and steering control completely and permanently, on all roads and in all situations. The driver or passenger sets a destination via a touchscreen. The driver or passenger cannot drive manually and perform interventions, because the vehicle does not have a steering wheel” (p. 131). A graphic scenario [21], for illustrating the application and utility of SDVs, showed the driver and passengers in rearward-facing seating arrangements having face-to-face interactions and read as follows: “The picture shows one possible application scenario of fully automated driving. Fully automated driving enables the driver (i.e., passengers) to perform more non-driving activities, such as reading a book, watching a film, surfing the Internet, playing their phones, dealing with their working affairs, sleeping, and so on and so forth. The driver and front seat passenger are able to swivel their seats and have a face-to-face communication and conversation.”

In this study, we only focused on public responses to the benefit-risk perception. Participants were required to weigh the risks and benefits of SDVs to society on a five-point scale with the following five options: “risks far outweigh benefits”, “risks outweigh benefits”, “risks and benefits are the same”, “benefits outweigh risks” and “benefits far outweigh risks” [22].

3 Results

Those who chose “risks far outweigh benefits” (2.4%) or “risks outweigh benefits” (17.8%) held the position of “risks > benefits” (20.3%; $n = 209$) (see Fig. 2); those who chose “benefits outweigh risks” (36.1%) or “benefits far outweigh risk” (6.3%) held the position of “risks < benefits” (42.4%; $n = 438$). Thus, those who perceived greater benefits outnumbered those who perceived greater risks by 2 to 1. The left 37.3% participants ($n = 385$) thought “risks = benefits”.

We coded the five responses from “risks far outweigh benefits” to “benefits far outweigh risks” as 1–5 and then conducted a regression analysis to examine the relationships between the benefit-risk perception (as a dependent variable) and demographic factors (as predictors). Four demographic factors affected the benefit-risk perception (see Table 1). Those who have heard about SDVs before the survey, male, older (≥ 40), and highly educated (with a college degree or higher) tended to believe that the benefits of SDVs outweigh their risks.

We summarized the percentage of the three opinion positions—risks > benefits, risks = benefits, and risks < benefits—among different segments of participants on the basis of the four demographic factors that associated with the benefit-risk perception (see Table 2). The relative percentage of participants holding the two polarized positions was usually reversed between groups in terms of each demographic factor. For instance, in the “risks > benefits” position, the percentage of participants holding this

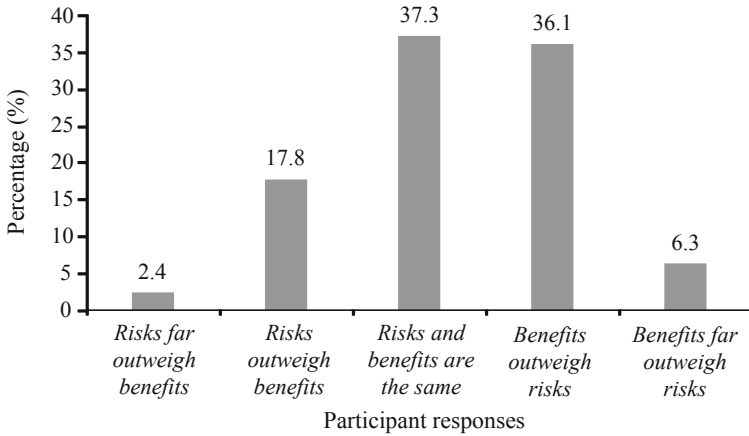


Fig. 2. Distribution of participant responses.

Table 1. Results of regression on benefit-risk perception.

Predictors	<i>B</i>	<i>SE</i>
Heard about SDVs (no = 0, yes = 1)	0.34***	0.07
Gender (male = 0, female = 1)	-0.24***	0.06
Age (<40 = 0, ≥ 40 = 1)	0.24**	0.08
Education (college and above = 1, others = 0)	0.21**	0.07
Occupation (civil servants and public sectors = 1, others = 0)	0.06	0.06
Income (>CNY5,000 = 1, others = 0)	0.03	0.06
Driver (driver license holder = 1, others = 0)	-0.10	0.06
<i>F</i> = 9.17, <i>p</i> < 0.001, <i>R</i> ² = 0.059		

Note: *B*, unstandardized coefficients; *SE*, standard error. ***p* < 0.01; ****p* < 0.001. 1 CNY ≈ 0.145 USD.

position in the male group (17.1%) was lower than that in the female group (23.8%). It was reversed in the “risks < benefits” position that the percentage of participants holding this position in the male group (49.0%) was greater than that in the female group (35.1%). This qualitative finding was also true for other three demographic factors.

Table 2. Benefit-risk perception by demographic factors

Perception	Heard about SDVs		Gender		Age		Education	
	No	Yes	Male	Female	<40	≥ 40	< college	≥ college
Risks > Benefits	33.3%	16.8%	17.1%	23.8%	20.8%	16.7%	26.0%	18.3%
Risks = Benefits	37.1%	37.4%	33.9%	41.1%	38.2%	31.9%	35.7%	37.9%
Risks < Benefits	29.6%	45.8%	49.0%	35.1%	41.0%	51.4%	38.4%	43.8%

4 Discussion

This analysis is one part of a multifaceted research that aims to understand public responses to SDVs. More than 50% participants (57.6%) did not believe that the benefits of SDVs outweigh their risks to society, and the left 42.4% thought benefits higher than risks. It might be an unwanted finding for promoters of SDVs.

SDVs might be a controversial technology in the future. We can see similar public responses to existing controversial technologies. For instance, Cobb and Macoubrie [13] surveyed the general American public's benefit-risk perception and found that sizeable percentage (38%) thought risks and benefits would be about equal, and slightly more (40%) thought that nanotechnology would produce more benefits than risks, while half that many (22%) said risks would outweigh the benefits.

Our finding would invoke findings on other kinds of public responses to SDVs. For example, a survey by Pew Research Center [23] showed that more Americans express worry than enthusiasm about the development of driverless vehicles: 40% were at least somewhat enthusiastic about this development, while 54% expressed some level of worry; 44% Americans say they would want to ride in a driverless vehicle if given the opportunity, whereas 56% Americans say they would not. We think, currently, the public do not show optimism toward SDVs.

Understanding the relationship between individual characteristics and the benefit-risk perception may provide practical insights for segmenting the future SDV market. Four demographic factors might influence the public's benefit-risk judgment. Participants who have heard about SDVs tended to perceive greater benefits versus risks. This finding might invoke the "familiarity hypothesis" in the risk-perception literature, which argues that higher level of familiarity forms more positive attitudes. Our previous study [29] also reported that those who have heard about SDVs were willing to pay more extra money for adding the SDV technology. Regarding the benefit-risk judgment, similar findings can be found in studies on nanotechnologies [11, 13]. The positive influence of familiarity is usually seen in the early period of a technology when media coverage may be more likely to communicate the benefits of this technology. When the public perceive more risks from the deployment of this technology, familiarity could induce a negative influence on the benefit-risk judgment.

Female participants tended to perceive greater risks versus benefits. This finding might invoke the gender difference identified in the risk-perception literature. Facing with emerging technologies, females usually express more concerns and worry for the same risks, perceive risks as more serious, take less risks, than males [14, 15, 24]. Different affective responses to technologies between females and males [12] might account for the gender difference in the benefit-risk perception. Hohenberger et al. [16] found that female participants expressed higher anxiety when they imaged to ride in an AV than male participants, which led them to have lower willingness to use AVs. Note that this gender difference might not be seen in other measures [25, 26, 29]. For example, we did not find the gender difference in the acceptable risk of SDVs [25] and the willingness to pay for the SDV technology [29].

Findings on the negative relationship between age and public acceptance of SDVs [17, 19, 29] may suggest a negative relationship between age and the benefit-risk

perception. Unexpectedly, a positive relationship was observed: older participants (age ≥ 40) tended to believe higher benefits versus risks than younger participants. Similarly, our previous work [6] found that older participants perceived higher benefits of SDVs than younger participants and these two groups did not report different risk concerns. The relationship between age and the benefit-risk perception deserves more explorations. SDVs promise to largely increase the mobility of senior populations who cannot drive themselves. Their benefit-risk perceptions will largely determine whether the society gains this mobility benefit.

Highly educated participants tended to perceive greater benefits versus risks. We do not have clear and specific accounts for this finding. We guess that these participants have a higher expectation that this technology can assure the purported benefits or they have more resources to seek out and to credit benefit information of the SDV technology. We should note certain studies did not find the significant influence of education on people's benefit perception and risk perception [6] and on intention to use [27] related to SDVs. However, we noted that education was a positive predictor to people's willingness to pay for the SDV technology [29].

5 Conclusions

Our survey focused on the public's benefit-risk perception of SDVs that was not addressed in past studies. Our participants were asked whether they think the risks of SDVs to society far outweigh their benefits to society, their risks outweigh their benefits, their risks are equal to their benefits, their benefits outweigh their risks, or their benefits far outweigh their risks. In sum, we found that 37.3% Chinese participants perceived SDVs' benefits to society are equal to their risks to society, 20.3% thoughts SDVs' risks higher than their benefits, and the left 42.4% thought SDVs' benefits higher than their risks. Thus, more than 50% participants did not have optimistic perceptions about SDVs. Four individual characteristics significantly influenced the benefit-risk perception. Those who have heard about SDVs before the survey, male, older (≥ 40), and highly educated (with a college degree or higher) tended to believe the benefits of SDVs higher than their risks. Reasoned public opinion does not spontaneously emerge from accumulating scientific information about the risks and benefits of a technology [28]. We suggest active, effective risk communication to prevent the SDV technology from becoming another controversial technology in society.

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