Implementing Social Value Orientation in Measuring the Health and Environmental Dilemmas of Autonomous Driving

Susilo, Y.O.*[1], Birgfellner, L.[2]

[1] Professor, Dept. of Landscape, Spatial and Infrastructure Sciences, University of Natural Resources and Life Sciences, Vienna, Austria
[2] Graduated master student, Dept. of Landscape, Spatial and Infrastructure Sciences, University of Natural Re-sources and Life Sciences, Vienna, Austria

SHORT SUMMARY

Understanding users' market reaction towards the positive and negative impacts of the technology as well as its trade-offs is essential to anticipate market reaction once the technology is deployed on the ground. Based on data from 1,000 Austrian participants, this study takes a deeper look into different demographic clusters on how different participants' values and behaviours influence their reaction towards the environmental and health impacts of an autonomous transport network. The results indicated that the respondents exhibited individual-oriented reactions regarding environmental impacts while demonstrating more altruistic reactions in the case of health-related impacts. Also, a distinction can be made between age groups, as older generations aged between forty and sixty revealed more altruistic reactions than younger participants. Despite an individualistic tendency towards environmental issues, when the respondents faced a choice between their own health and the common good, they prioritised the latter.

Keywords: social value orientation, trade-off mechanisms, autonomous driving impacts.

1. INTRODUCTION

In the last decade, there have been a large amount of studies in the field of automation and digitalisation, including in autonomous driving technology. Dozens of previous studies (e.g Narayan et al. 2020; Galich and Stark, 2021; Davemos, 2021) highlighted the plausible impacts of autonomous technology and the market enthusiasm to adopt the technologies. Some are highlighting the benefit of the technology. For example, Gurumurthy and Kockelman (2018) shows that ride-sharing autonomous service can lead to a reduction of vehicular traffic flow: at least 50% of single-person trips (based on the trip data collected from smartphone application) across 1,267 zones over 30 days in the Orlando metropolitan area. Furthermore, replacing low-demand bus lines with an automated shuttle service can potentially enhance overall bus service quality by reducing passenger-vehicle-kilometres for passengers, while accruing higher profit per kilometre for the service's operators (Shen et al., 2018). At the same time, other studies (e.g. ITF, 2018; Litman et al., 2022) however also highlights the less favourable impacts, including the increase of infrastructure costs, the increase of travel distance, pollutions and sprawl-related costs, etc.

Whilst there have been large amount of studies explore the individual acceptance towards the technologies (e.g. Nordhoff et al., 2020; Chee et al., 2020; Kaye et al., 2020), many of these studies were focused on public/users' acceptance of the technology as a function of users'/repondents' perceptions, preferences and travel needs. For example, Nordhoff et al. (2020) explored the public acceptance of partially automated (SAE Level 3) passenger cars by means of a questionnaire among 9,118 drivers in eight European countries and Kaye et al. (2020) examined the a priori acceptance of highly automated cars through the Theory of Planned Behaviour (TPB) and

the Unified Theory of Acceptance and Use of Technology (UTAUT) in Australia, France and Sweden. These studies, however, are only focussing on the acceptance of the technology per se, and not about the trade-off mechanisms, between positive and negative impacts, that underlying one's acceptance of the technologies – and this study aims to address this research gap.

Using Social Value Orientation (SVO) framework approach, this study takes a deeper look into how different participants' values and behaviours influence their individualistic and altruistic behaviours towards the environmental and health impacts of an autonomous transport network.

In the next sections, the Social Value Orientation (SVO) framework and data collection were described. Then it is followed by a section which reported briefly the analysis results and the abstract is closed with a brief conclusion.

2. METHODOLOGY

In this study a primary data collection, through an online questionnaire, which focuses on how respondents' SVO influences, values and weights the positive and negative impacts of environmental and health impacts that may be caused by an autonomous transport network implementation, was deployed. The links between individual behaviours and the participants' appreciation of the technology's impacts are measured primarily via three pillars. The first pillar focuses on the individual's value orientation towards *money*. This pillar was chosen as it is one of the most influential and commonly used indicators in standard transport analyses; moreover, many behavioural studies also use the medium of money to investigate individual SVOs (Murphy et al., 2011). The second pillar in this value orientation investigation is *safety*. This pillar meant to examine whether the respondents would place their own safety above others and to what extent. Ensuring operational safety for users and the environment is one key point behind people choosing to use AVs, whilst at the same time traffic accidents caused by human and technical failures cannot be ruled out (Fagnant & Kockelman, 2018). The environmental pillar represents the third area of interest. If a respondent claimed a higher proportion on one pillar/aspect for him/herself, an individualistic behaviour can be attributed to him or her for the respective topic. An altruistic assessment would be based on a balanced distribution chosen by the participant.

Context Framework

The survey intended to find out about social tendencies between generations, gender, income classes, educational degree and place of residence. This experiment involved questioning over 1,000 people in Austria, with the following distribution of responses in mind:

- Male / Female participants ratio 50 / 50
- Urban / Rural ratio 50 / 50
- Generation Z (age 8 – 23) 20 – 30%
- Generation Y (age 24 – 39) 20 – 30%
- Generation X (age 40 – 55) 20 – 30%
- Baby Boomers (age 56 – 75) 20 – 30%

Questionnaire design

The questionnaire was divided into three sections. The first part was devoted to capture participants confidence in and understanding of the new technology. The second part quantified SVO based on Murphy et al. (2011). Trends and the participants' social attitudes were measured based on the accumulated pronouncements of six different scales offering a variety of nine decisions.

Figure below depicts an example of one of the six scales in which the test subjects had to choose an amount they would claim against a third party unrelated to them.

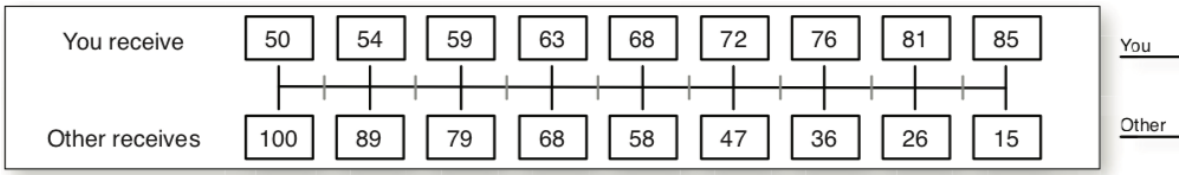


Figure 1: SVO Slider Items participants can choose

Through this measurement, we then group participants' behaviour into the following four categories using a mathematical model called the "Slider Method," which calculates a decision's angle. The measurement consists of six decision options, each with nine secondary decision options. All have the same limit and amount in their resource allocation, based on which the respondents can make his/her decision. Each decision includes a split payoff that is predetermined calculated from the participant's decision. For example, the respondent chooses a value x between 50 and 100. The payoff for him would be x, whereas, for the third party, the payoff is 150 - x. Whilst the respondent chooses his individual preference between the nine decision options and thus also determines the payoff a third party receives. Based on the response, then we classify the respondents according to the scale as below:

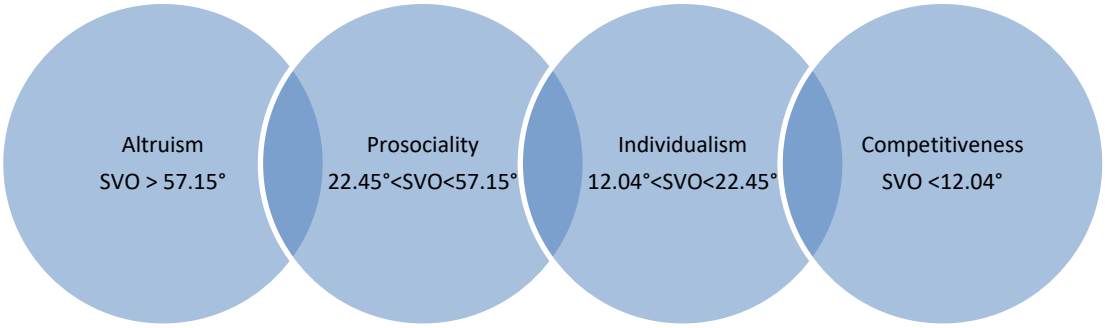


Figure 2: Social Behaviour categories

3. RESULTS AND DISCUSSION

Sample profile

The collected sample profile can be seen on Figure 1 below. Overall, we have a fair distribution between male and female, with higher percentage of young adult respondents. In terms of geographical distribution, 59% of the participants were from rural areas, and around 40% were in urban areas. Large proportion of the respondents are university level educated with medium upper income level.

Table 1: Sample Profile

	Frequency	Per cent
Gender of respondents		
prefer not to tell	1.0	0.1
female	520.0	47.4
male	577.0	52.6
Total	1098.0	100.0
Age of respondents		
18-20	182.0	16.6
20-30	371.0	33.8
30-40	304.0	27.7
40-50	187.0	17.0
50-60	53.0	4.8
>60	1.0	0.1
Total	1098.0	100.0
Location of respondents		
Annweiler	1.0	0.1
Bruck an der Mur	1.0	0.1
Graz	53.0	4.8
Hinterglemm	1.0	0.1
Innsbruck	53.0	4.8
Linz	4.0	0.4
Lustenau	1.0	0.1
Rural	648.0	59.0
Salzburg	3.0	0.3
Vienna	331.0	30.1
Total	1096.0	100.0
Income of respondents		
N/A	7.0	0.6
to € 1,500	138.0	12.6
to € 2,000	133.0	12.1
to € 2,500	260.0	23.7
to € 3,000	368.0	33.5
to € 5,000	192.0	17.5
Total	1098.0	100.0
Highest degree of respondents		
N/A	66.0	6.0
High school	313.0	28.5
Bachelor’s	495.0	45.1
Master’s	184.0	16.8
PhD	40.0	3.6
Total	1098.0	100.0

As we can see from Figure 3 below, there is a clear attitude among our respondents towards the technology. Over 90% would use an autonomous vehicle, and the majority would pay more for it. At the same time, around 80% expressed concern about relinquishing full control to an autonomous vehicle and almost 70% were aware of the negative environmental effects of an autonomous network.

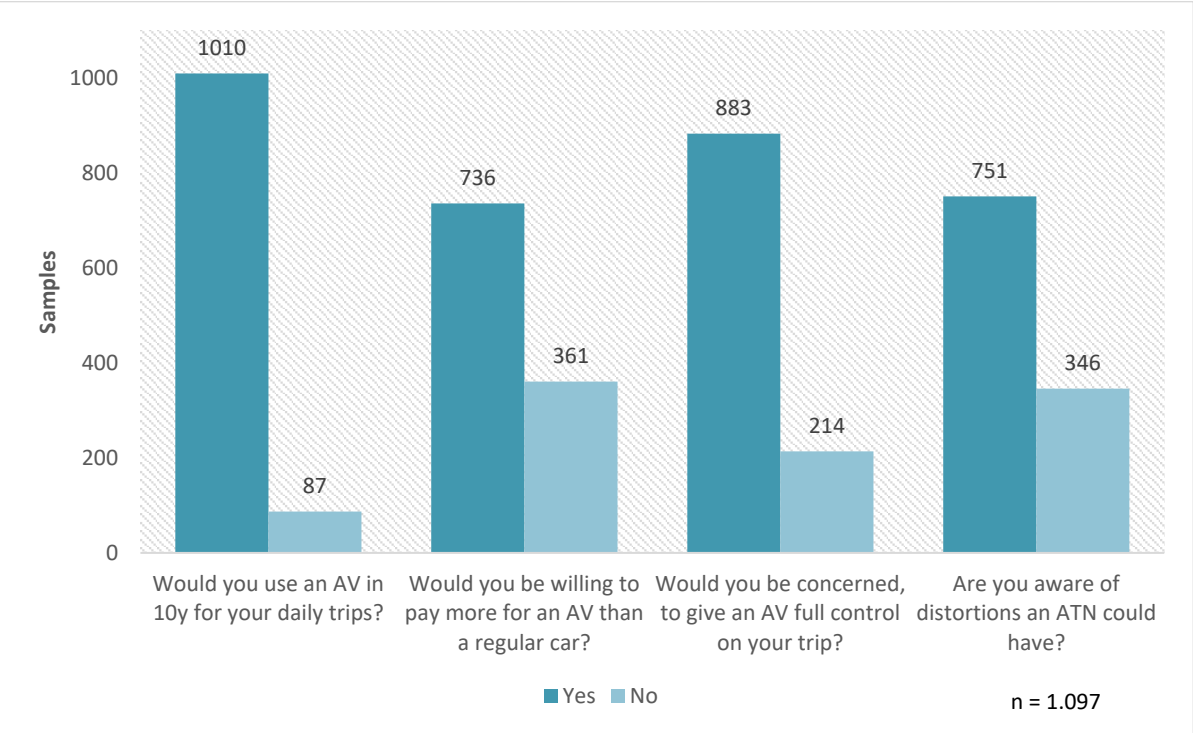


Figure 3: Possible attitudes towards autonomous vehicles

Social Value Orientation

In SVO analysis, we quantify respondents' value orientation through respondent's choice of distributing benefits and disbenefits to him/her (as a decision maker/DM) and to a third party. The respondent, who is also the DM, decided the amount he/she would claim for himself/herself and the amount he/she would distribute to a third party he/she did not know. Here are two examples of how the DM might have decided:

Option 1	Option 2
$85 to the DM	$100 to the DM
$85 to another person	$50 to another person

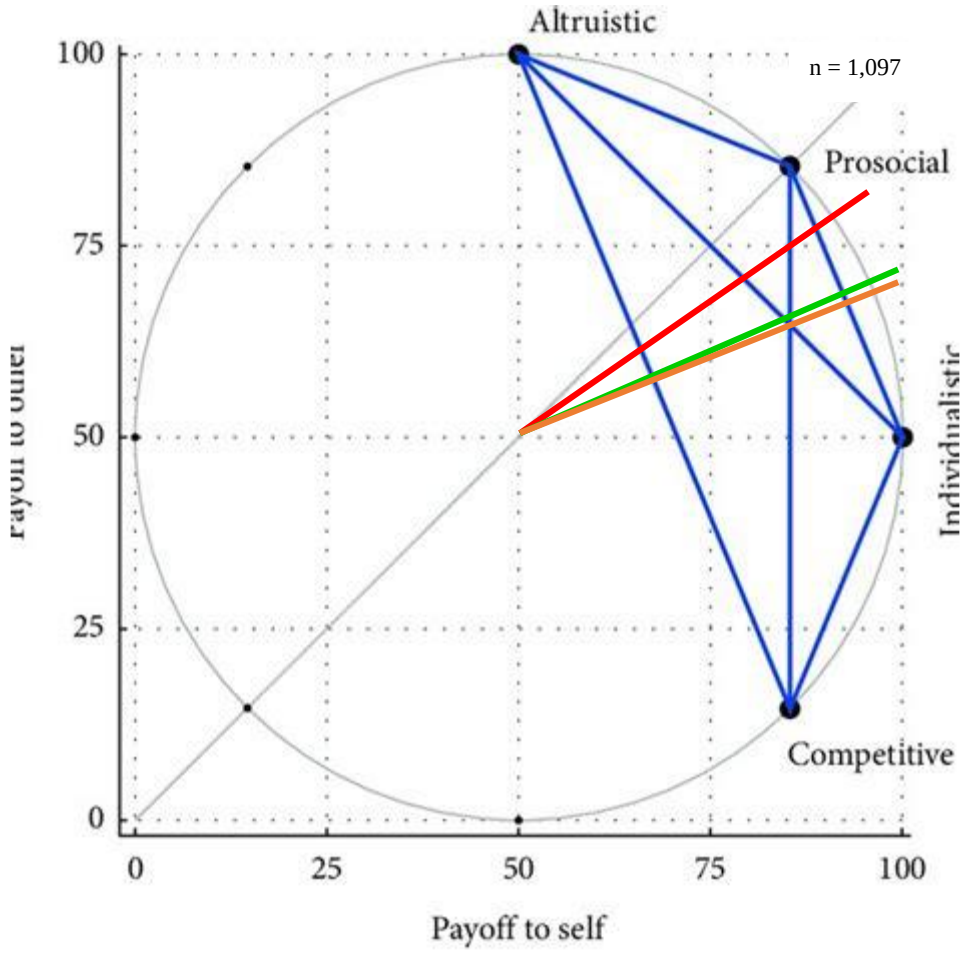
Option one represents a rational decision, whereas option two is considered an individualistic variant by maximum profit for oneself. The DM would penalise the other person by $35 to get an additional $15. In this study, the monetary decision-making process for money distribution was examined along with value orientations of environment and safety. The last two pillars' units were defined by land area in square metres and a higher probability of survival in a traffic network. The calculation process for the three different SVOs was as follows (the example calculated the SVO for money, but the method was the same for the other two):

First, the respondents' distribution options were collected and subtracted by 50. Both the mean of the DM and the third party were determined, and the ratio of the two was calculated. The inverse tangent was then calculated from this result to determine a representative angle in the coordinate system.

$$\arctan\left(\frac{mean\ to\ self - 50 * scale}{mean\ to\ other - 50 * scale}\right) \qquad (1)$$

As already described in the methodology section, social forms of value orientation can be determined by calculating the different angles, as below:

$$1 = \text{Altruist} \Leftrightarrow \texttt{svo\_angle} > 57.15,$$
$$2 = \text{Prosocial} \Leftrightarrow 57.15 \geq \texttt{svo\_angle} > 22.45,$$
$$3 = \text{Individualist} \Leftrightarrow 22.45 \geq \texttt{svo\_angle} > -12.04$$
$$4 = \text{Competitive} \Leftrightarrow \texttt{svo\_angle} \geq -12.04$$



In the evaluation of the 1,097 participants, the SVO shows 27° for money (orange), 37° for health (red), and 28° for the environment (green). With these results, all three characteristics of the study contrast in prosocial value orientation. In analysing these three pillars, the SVO of health is positioned much more altruistically, placing itself relatively precisely between the two orientations of the individualistic and prosocial forms. This outcome indicates the DMs were a lot more generous

with their “fellow human beings” in the decision-making process regarding security (Murphy et al., 2011).

Multivariate analysis

To understand better on how SVO values vary across socio-demographic variables, a series of regression models were carried out. Through a series of estimations, we found significant differences between gender, revealing women as greater individual benefit maximisers than men. This result is not in-line with the previous studies which many indicated that the females are having a more altruistic value orientation than men (e.g. Liebrand & van Run, 1985).

All participants living in rural areas show a more altruistic behaviour than participants who live in urban areas. Furthermore, when examining the different age groups, an increase in SVO corresponds to increasing age. A continuous increase can be noted both in the orientation towards the environment and in health. This phenomenon is also consistent with the literature review. In Hellevik’s study on “Age Differences in Value Orientation”, a direct connection between different value orientations with increasing age was evident. This relationship is explained by a modern, materialistic behaviour structure, especially in age groups that grew up in the 80s and 90s. The economic upswing after the war initially resulted in a materialistic disinterest. However, in 1980, economic security became more dominant and led to more individualistic behaviour (Hellevik, 2002). In terms of income variables and education, no patterns could be identified among the studied three value orientations.

4. CONCLUSIONS

This study aimed to identify how personal SVO influence one’s valuation of benefits and disbenefits environmental and health impacts and subsequently one’s individualistic and altruistic behaviours. Based on an observation from more than 1,000 Austrian participants, it can be concluded that in term of valuing benefits and disbenefits of an autonomous transport network impacts, our respondents tend to be more individualistic, and put his/her own interest above others. Higher-income groups with increased concerns about autonomous cars displaying a higher SVO result when purchasing an AV because of their better financial situation. The rural participants demonstrate a more altruistic attitude on safety and environmental aspects. The results also reveal that some older generations had a more altruistic attitude than younger ones.

While the used tool of SVO limits the generalizability of the results, this approach provides new insight on measuring and investigating the dilemma and trade-off underlying individualistic and altruistic behaviours, which subsequently influence their acceptance towards certain benefits and disbenefits to oneself and others.

ACKNOWLEDGMENT

The earlier version of this work is a part of the second author’s master thesis at the University of Natural Resources and Life Sciences (BOKU), Vienna. The work is supported by the BMK/FFG Endowed Professorship programme in digitalisation and automation in mobility system, DAVeMoS.

REFERENCES

Chee, E.P.N, Susilo, Y.O., and Wong, Y.D. (2020) Determinants of Intention to Use First-/Last-mile Shared Autonomous Bus Service. Transportation Research part A, 139, pp. 350 - 375.
DAVeMoS (2021) Knowledge Pool, accessible at: https://www.davemos.online/knowledge-pool (accessed 22 January 2022)
Fagnant, D. J., & Kockelman, K. M. (2018). Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas. Transportation, 45(1), 143–158.
Galich, A., & Stark, K. (2021). How will the introduction of automated vehicles impact private car ownership? Case Studies on Transport Policy, 9(2), 578–589
Gurumurthy, K. M., & Kockelman, K. M. (2018). Analyzing the dynamic ride-sharing potential for shared autonomous vehicle fleets using cellphone data from Orlando, Florida. Computers, Environment and Urban Systems, 71(June), 177–185.
Hellevik, O. (2002). Age Differences in Value Orientation—Life Cycle or Cohort Effects? International Journal of Public Opinion Research, 14(3), 286–302.
ITF (2018), Safer Roads with Automated Vehicles? International Transport Forum (www.itf-oecd.org); at
Kaye, S. A., Lewis, I., Forward, S., & Delhomme, P. (2020). A priori acceptance of highly automated cars in Australia, France, and Sweden: A theoretically-informed investigation guided by the TPB and UTAUT. Accident Analysis and Prevention, 137, 105441.
Liebrand, W. B. G., & van Run, G. J. (1985). The effects of social motives on behavior in social dilemmas in two cultures. Journal of Experimental Social Psychology, 21(1), 86–102.
Litman, T. (2022), Autonomous Vehicle Implementation Predictions: Implications for Transport Planning, Victoria Transport Policy Institute
Murphy, R. O., Ackermann, K. A., & Handgraaf, M. (2011). Measuring Social Value Orientation. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.1804189
Narayanan S, Chaniotakis E, Antoniou C. 2020. Shared Autonomous Vehicle Services: a Comprehensive Review. *Transportation Research Part C: Emerging Technologies*. Vol. 111, pp. 255-293.
Nordhoff, S., Louw, T., Innamaa, S., Lehtonen, E., Beuster, A., Torrao, G., Bjorvatn, A., Kessel, T., Malin, F., Happee, R., & Merat, N. (2020). Using the UTAUT2 model to explain public acceptance of conditionally automated (L3) cars: A questionnaire study among 9,118 car drivers from eight European countries. Transportation Research Part F: Traffic Psychology and Behaviour, 74, 280–297.
Shen, Y., Zhang, H., & Zhao, J. (2018). Integrating shared autonomous vehicle in public transportation system: A supply-side simulation of the first-mile service in Singapore. Transportation Research Part A: Policy and Practice, 113(June 2017), 125–136.
www.itf-oecd.org/sites/default/files/docs/safer-roads-automated-vehicles.pdf.