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Do Open-ended Questions Influence the Measurement of Attitudes? An Investigation

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Abstract

Measuring attitudes is gaining even more importance in travel behavior research. Previous research indicates that the open-ended questions prime closed-ended responses. In this research, we use a questionnaire that analyses the stated choice of use of autonomous vehicles (AV). Attitudes are measured using an extended version of the Technology Acceptance Model. Two questionnaire versions were used to collect data from 2000 respondents from the USA. An integrated latent variable and choice model was estimated to predict the intention to use AVs for commute trips. The models' performance along with the estimated for the two datasets were compared.

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Keywords: Attitudes in Travel Behaviour Research, Likert scale questions, Central Tendency Bias, Non-trading Respondents, Integrated Choice and Latent Variables Model, Autonomous Vehicles

1. Introduction and Background

Measuring and analyzing attitudes has been of interest to researchers/analysts in numerous domains of research such as psychology (Plant, 1922), politics (Geer, 1988), medicine (Sun et al., 2020), and travel behavior research (Baburajan et al., 2021; Kaplan et al., 2015). To measure attitudes, researchers use open- or closed-ended questions. For instance, to measure the attitudes towards the cycling experience, one could you closed-ended questions such as, "*On a 5-point scale, rate your cycling experience*" or an open-ended question such as "*how is your cycling experience*". Researchers/analysts have mostly used closed-ended questions, considering convenience, easiness in use, and swifter

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operation (Bowling, 2005; Converse, 1984). Since the focus of this paper is on the impact of closed-ended questions to measure attitudes, we will focus on literature related to closed-ended questions.

In the closed-ended approach, researchers/analysts present statements describing the attitudes along with a scale to the respondents, who then choose points on the scale that best describes their attitude. When researchers are interested in measuring bipolar attitudes, they use bipolar scales that range between the two extremes ("Strongly disagree" to "Strongly agree"). For research problems that measure the intensity of attitudes, they use unipolar scales ("Not at all satisfied" to "Extremely satisfied") (Krosnick and Fabrigar, 1997). Every participant answering a closed-ended question proceeds through the following four stages- a. *interpret the question;* b. *recognizes the attitude being measured;* c. *recollects their beliefs and feelings;* and d. *relate the attitudes to a point on the scale that best describes their attitudes* (Tourangeau and Rasinski, 1988).

Before choosing a scale, researcher/analyst must make careful considerations regarding the type (unipolar/bipolar), length, labelling (Krosnick and Fabrigar, 1997). Researchers often debate about the inclusion of a mid-point on the scale, as on one side, their exclusion could reduce number of neutral responses (Bowling, 2005) and avoid social desirability bias (Garland, 1991). On the other hand, their exclusion might suppress the opinions of truly neutral individuals (Matell and Jacoby, 1972). The widespread use of online surveys to measure attitudes have led to a host of other problems. Research findings indicate that respondents tend to be more sensitive to the scales (Wells et al., 2014) and their visual presentation (Weijters et al., 2020) in online surveys.

In this paper, we focus on the use of closed-ended questions to measure attitudes. Particularly, we are interested in analyzing the influence of open-ended questions on the responses to closed-ended questions and stated-preference responses. We pursue this research, particularly considering our previous findings ((Baburajan et al., 2021, 2018)) that indicate that open-ended questions placed before a set of Likert scale questions reduces the neutral responses. To the best of our knowledge this is the first time that open ended questions are introduced in a survey collecting attitudes through closed end questions, aiming to study its effect on the responses to the latter type of questions.

The rest of the paper is organized into five sections. The questionnaire design and the data collection are presented in Section 2. Section 3 discusses findings of our exploratory analysis and Section 4 the modelling framework. In the penultimate section, we elaborate the analysis results before summarizing the concluding remarks in the final section.

2. Questionnaire Design and Data Collection

To investigate the influence of open-ended questions on closed-ended questions, we designed a questionnaire that measured attitudes towards Autonomous Vehicles (AVs) and the intention to use AVs for commute trips using a stated preference experiment. When comparing the two datasets (Likert scales without priming [Ver_LK] and Likert scales without priming [Ver_LKOE]), psychological construct, statements used, the choice experiment, and the representativeness of the dataset might affect the comparison. To address this, we adopted the psychological construct (an extension of the Technology Acceptance Model [TAM]) and the statements to measure attitudes from Zhang et al. (2019). Furthermore, the stated preference experiment was adopted from Haboucha et al. (2017) and finally to address issues related to the samples, we ensured that they were representative of the population of United States of America based on key socio-demographic characteristics. We believe that ensuring these will facilitate a comparison of the two datasets. Data was collected from the USA using an online panel provider Cint. The alternative questionnaire types were presented randomly to the respondents using the Randomizer feature in Qualtrics. Data was collected between January and March 2020. A detailed description of the data collection is presented in Baburajan et al. (2022).

3. Results of Exploratory Analysis

To pursue the objectives of our research, we first assess if the two datasets are comparable. In this regard, we compare the socio-demographic characteristics of the respondents. Having done this, we evaluate the differences in the Likert scale responses for the two datasets. To evaluate if the observed differences are statistically significant, we estimate an Ordered Probit models for each of the Likert scale questions. Furthermore, we analyse the influence of open-ended questions on the choice variable. Accordingly, we assess the frequency distribution of the choice variable.

Later, we estimate a Multinomial Logit model for mode choice to evaluate if the observed differences in mode choice with the introduction of open-ended questions is statistically significant.

3.1. Socio-demographic Characteristics

In the sample we collected, more than 50% of respondents were women. The average age was about 38.69 (std. dev.- 13.91) and the Ver_LKOE had a slightly higher representation of respondents earning between $50,000 and $74,999 and possessing bachelor's/graduate degree. In our sample, the representation of European American was about 70%, African American about 14-18%. When evaluating the employment status, about 55% were full-time, 30% were part-time and the remaining identified themselves as students.

3.2. Differences in Attitudes for the Two Versions of the Questionnaire

As we discussed previously, we used an extended version of the TAM. The statements used in the analysis are presented in Appendix C in Baburajan (2021). We first analyzed the internal consistency of the statements using Cronbach's alpha, Kaiser-Meyer-Olkin (KMO) and the percentage of variance explained. Comparing the values presented in Table 1, it can be observed that the values for these parameters are slightly higher for Ver_LKOE.

Table 1 Comparison of Reliability and Extracted Factors.

Attitudes	Cronbach's alpha		KMO		% Variance Explained	
	Ver_LK	Ver_LKOE	Ver_LK	Ver_LKOE	Ver_LK	Ver_LKOE
Perceived Ease of Use	0.905	0.908	0.842	0.847	77.83	78.53
Perceived Usefulness	0.830	0.841	0.810	0.819	59.84	61.72
Perceived Safety Risk	0.839	0.863	0.500	0.500	86.27	88.13
Perceived Privacy Risk	0.912	0.918	0.728	0.733	85.10	85.93
Trust	0.878	0.907	0.733	0.734	80.91	85.01
Attitudes towards AVs	0.891	0.914	0.716	0.722	82.12	85.45

To assess the role of open-ended questions on responses, we estimated ordered Probit models for the responses to each of these statements. Age, household income, professional qualification and questionnaire type were included in the model. Ordered Probit models were used considering the ordinal nature of the Likert scale responses. More information of the principles and estimation of Probit models can be obtained from Greene and Hensher (2010). The second column presents the coefficients relative to the questionnaire type along with its statistical significance. Referring to the Table 2, it can be observed that the differences in the distributions of the Likert scale responses for nearly 60% of the statements are statistically significant at 90% confidence interval.

Table 2 Comparison of the statements for the two versions of the questionnaire

Statements depicting attitudes	Coefficient
Perceived Ease of Use (PEoU)	
PEoU1- Learning to use Autonomous Vehicles will be easy for me	0.076
PEoU2- I will find it easy to get Autonomous Vehicles to do what I want them to do	-0.020
PEoU3- It will be easy for me to become skillful at using Autonomous Vehicles	0.104**
PEoU4- I will find Autonomous Vehicles easy to use	0.058
Perceived Usefulness (PU)	
PU1- Using Autonomous Vehicles will be useful in meeting my travel needs	0.035
PU2- Autonomous Vehicles will let me do other tasks such as eating, watching a movie, be on a cellphone during my trip	0.162***

PU3- Using Autonomous Vehicles will decrease my accident risk	0.153***
PU4- Using Autonomous Vehicles will relieve my stress of driving	0.106**
PU5- I find Autonomous Vehicles to be useful when I'm impaired	0.143***
Perceived Safety Risk (PSR)	
PSR1- I'm worried about the general safety of such technology	0.106**
PSR2- I'm worried that the failure or malfunction of Autonomous Vehicles may cause accidents	0.148***
Perceived Privacy Risk (PPR)	
PPR1- I'm concerned that Autonomous Vehicles will collect too much personal information from me	-0.180***
PPR2- I'm concerned that Autonomous Vehicles will use my personal information for other purposes without my authorization	-0.136***
PPR3- I'm concerned that Autonomous Vehicles will share my personal information for other purposes without my authorization	-0.110**
Perceived Trust (Tr)	
Tr1- Autonomous Vehicles are dependable	0.051
Tr2- Autonomous Vehicles are reliable	0.039
Tr3- Overall, I can trust Autonomous Vehicles	0.056
Attitudes (ATT)	
Att1- Using Autonomous Vehicles is a good idea	0.115**
Att2-Using Autonomous Vehicles is a wise idea	0.110**
Att3-Using Autonomous Vehicles is pleasant	0.042

Note: ***, **, * ==> Significance at 1%, 5%, 10%

Moving on to the influence of open-ended questions on the stated preference choices, from Fig. 1, one can infer that the distribution for mode choice variable changes with the introduction of the open-ended question. We then analyzed if this difference was statistically significant, for which we estimated a Multinomial Logit (MNL) model for the mode choice, by including the "questionnaire type" as an independent variable. We direct readers interested in knowing more about MNL to Ben-Akiva and Lerman (1985). The questionnaire type was statistically significant for both "Private AV" and "Shared AV" at 99% confidence interval (Private AV- 0.355***, Shared AV- 0.383***).

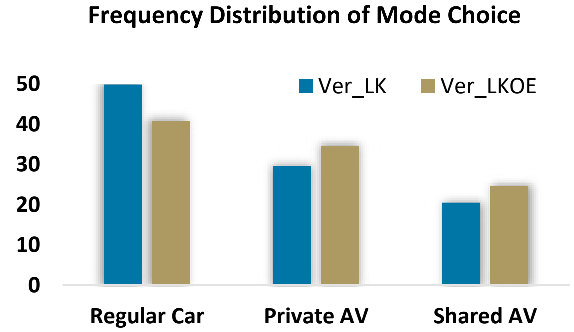

Fig. 1 Frequency distribution of mode choice

4. Modelling Framework

To develop a model for mode choice for commute trips (a nominal variable) after incorporating attitudes, we used the Integrated Latent Variable and Choice (ICLV) model (Walker and Ben-Akiva, 2002). Since the socio-demographic characteristics were similar for both versions of the questionnaire, we did not model its influence. For the estimation, we included only variables related to the attitudes and the Stated Preference experiments. The models were estimated using MPlus 8.2 (Muthén and Muthén, 2021), with the code provided by Temme et al. (2008). We present below in Fig. 2 our proposed modelling framework. The corresponding equations are as follows: -

$$U_{ni} = V(X_{ni}, \eta_{ni}; \beta) + v_{ni} \tag{1}$$

$$P(u_{ni} = 1 \,|X_{ni}, \eta_{ni}; \beta) = \frac{e^{V(X_{ni}, \eta_{ni}; \beta)}}{\sum_{j \in C_n} V(X_{ni}, \eta_{ni}; \beta)} \tag{2}$$

$$V_{ni} = \boldsymbol{\beta'}_x \boldsymbol{X}_{ni} + \boldsymbol{\beta'}_\eta \boldsymbol{\eta}_{ni} \tag{3}$$

$$\boldsymbol{y}_{ni} = \boldsymbol{\Lambda_y \eta}_{ni} + \boldsymbol{\varepsilon}_{ni} \tag{4}$$

$$\boldsymbol{z}_{ni} = \boldsymbol{\Lambda_z \xi}_{ni} + \boldsymbol{\delta}_{ni} \tag{5}$$

$$\boldsymbol{\eta}_{ni} = \mathbf{B}\boldsymbol{\eta}_{ni} + \boldsymbol{\Gamma\xi_{ni}} + \boldsymbol{\zeta}_{ni} \tag{6}$$

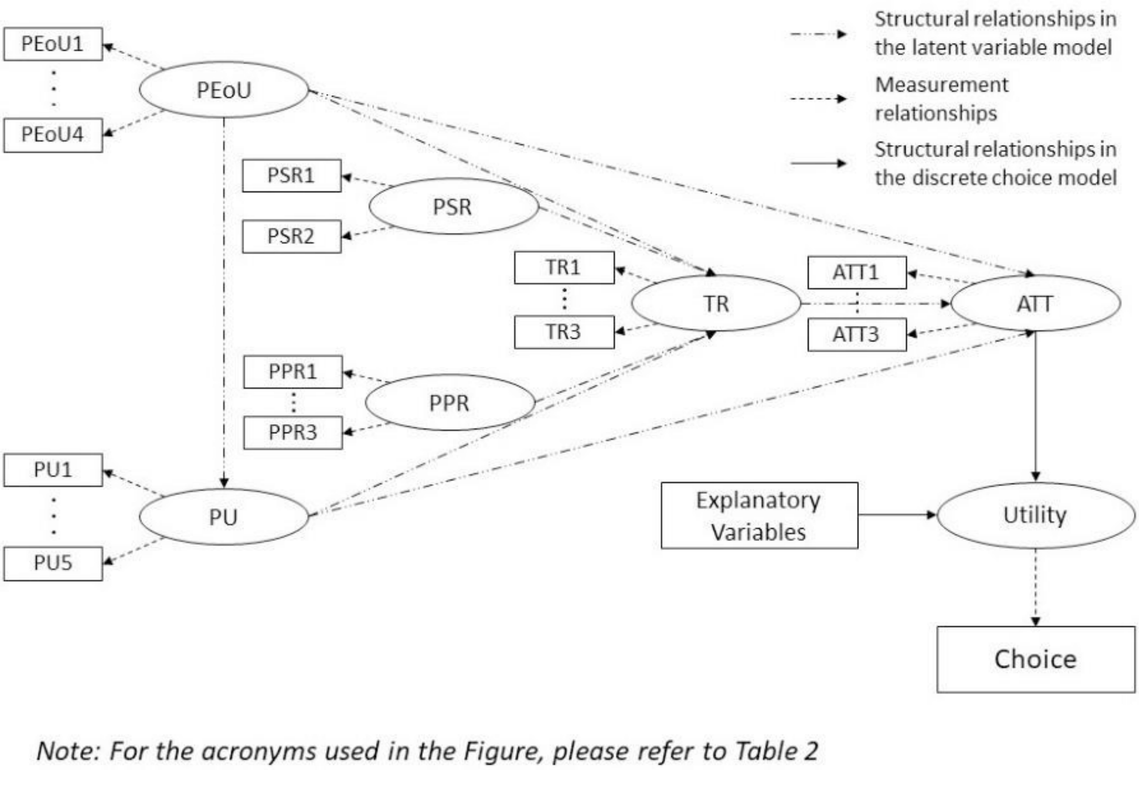

Fig. 2 Proposed Framework for the Extended Technology Acceptance Model for Choice

In the equations above, eq. (1) is the utility equation for the discrete choice model [$V(X_{ni},\eta_{ni};\beta)$- deterministic component, v_{ni}- stochastic component]. The endogenous latent variables and attitudes are represented using $\mathbf{X}_{ni}$ and $\boldsymbol{\eta}_{ni}$ respectively. The equations for the probability and the deterministic utility components are depicted using equations (2) and (3). The latent variables used in our model could be exogenous or endogenous. The measurement model for the endogenous variables is presented in equation (4). $\mathbf{y}_{ni}$ is a (P x 1) vector, Λ_y is a (P x M) matrix of factor loadings, and ε_{ni} is a (P x 1) vector of measurement errors that are i.i.d. multivariate normal. Equation (5) is the measurement model for the exogenous variables, and z_{ni} is a (Q x 1) vector, Λ_z is a (Q x N) matrix of factor loadings, and δ_{ni} is a (Q x 1) vector of measurement errors that are i.i.d. multivariate normal. In the structural equation for the latent variables (refer to Eq. (6)), $\mathbf{B}$ is an (M x M) matrix, $\boldsymbol{\Gamma}$ is an (M x N) matrix, and ζ_{ni} represents random disturbances that are i.i.d. multivariate normal.

5. Estimation Results and Discussion

Results of our analysis reinforce the observations of Zhang et al. (2019), that these constructs are effective in measuring these attitudes. The belief that it will be easy to learn how to use AVs, easy to use, get them to do what the user wants it to, and become skilful at using it influences *Perceived Ease of Use*. Furthermore, *Perceived Usefulness* was driven by AVs' ability to meet driving needs (particularly when drowsy, drunk, etc.) and multi-task during travel. The perception that it decreases accident risk and alleviate driving stress also contributed to *Perceived Usefulness*. Overall, the coefficients for both versions of the questionnaire for the full and cleaned dataset have similar effects (same direction of sign).

The worries about the general safety of such technology and accidents due to failures or malfunctions of AVs influence *Perceived Safety Risk*. In contrast, concerns stemming from the view that it might collect too much information, use personal information without consent, and share it with authorities governs *Perceived Privacy Risk*. The perception that AVs are dependable, reliable and can be trusted influences the *Trust* in AVs, and the perception that it is a wise/good idea and using AVs is pleasant affects the overall *Attitudes* towards AVs.

In their research, Zhang et al. (2019) observed that *Perceived Usefulness* and *Trust* influenced *Attitudes* towards AVs. We obtain similar results for models estimated using Ver_LK for the entire dataset, but for both versions of the cleaned dataset and Ver_LKOE of the entire dataset, we observed that *Perceived Ease of Use* also influenced *Attitudes*. Moving on, *Perceived Ease of Use* influenced *Perceived Usefulness* positively. In their study, Zhang et al. (2019) did not find *Perceived Ease of Use* and *Perceived Privacy Risk* to influence *Trust*- which they reported surprising. However, we observed *Perceived Ease of Use*, *Perceived Usefulness* to influence *Trust* positively and *Perceived Safety Risk* and *Perceived Privacy Risk* to influence *Trust* negatively.

Moving on to the discussion of the parameter estimates for the choice model, also presented in Table 3, we find the coefficients for the variables in the SP experiment to be meaningful. The purchase cost for *Regular Car* and *Private AV* negatively influences its choice, so does travel cost and parking cost on corresponding choices. Moreover, membership cost for *Shared AVs* has a negative influence on the choice of *Shared AVs*. *Perceived Usefulness* for AVs had a positive influence on the choice of both *Private* and *Shared AVs*, although *Attitude* towards AVs had an influence only on the choice of *Private AVs*.

While evaluating the performance of the estimated models, we observe higher values for the rho squared for Ver_LKOE. The results emphasise that the difference in the distribution of attitudes and the SP responses in Ver_LKOE eventually contributes to improved performance, emphasising the influence of open-ended questions (that act as priming) on the Likert scale questions.

Table 3 Results of the Estimation for the ICLV model

	Ver_LK		Ver_LKOE			Ver_LK		Ver_LKOE	
	Coeff	**t-stat**	**Coeff**	**t-stat**		**Coeff**	**t-stat**	**Coeff**	**t-stat**
Structural Equation Model									
Perceived Ease of Use (PER_EU) by					**Perceived Usefulness (PER_US) by**				
PEoU1	1	999	1	999	PU1	1	999	1	999
PEoU2	1.138	33.593	1.465	32.056	PU2	0.687	28.631	0.42	30.203
PEoU3	1.647	30.291	1.732	30.468	PU3	0.926	31.083	0.878	35.685
PEoU4	1.798	27.508	2.086	28.489	PU4	1.174	30.433	0.871	34.184
Perceived Privacy Risk (PER_PR) by					PU5	0.596	29.367	0.418	30.025
PPR1	1	999	1	999	**Perceived Safety Risk (PER_SR) by**				
PPR2	3.093	9.384	4.388	8.906	PSR1	1	999	1	999
PPR3	2.069	24.428	2.26	26.292	PSR2	1.238	21.292	1.282	20.671
Trust (PER_TR) by					**Attitudes (PER_AT) by**				
Tr1	1	999	1	999	Att1	1	999	1	999
Tr2	1.638	31.817	1.493	35.985	Att2	0.934	32.756	1.117	31.346
Tr3	2.015	25.809	1.991	26.571	Att3	0.609	34.555	0.623	38.763

Measurement Equation and Stated Preference Experiments				
Perceived Ease of Use (PER_EU) on				
PER_EU	0.803	46.744	1.198	51.513
Trust (PER_TR) on				
PER_EU	0.147	9.155	0.069	3.814
PER_US	0.477	29.086	0.554	38.672
PER_SR	-0.225	-23.097	-0.248	-25.908
PER_PR	-0.064	-7.09	-0.057	-5.366
Attitudes (PER_AT) on				
PER_EU	0.015	0.739	0.064	2.442
PER_US	0.828	27.844	0.827	30.518
PER_TR	1.17	38.528	0.785	26.397
Private Autonomous Vehicles on (Choice Model)				
Constant	-0.742	-14.025	-0.132	-2.3
PER_US	0.222	4.076	0.33	5.734
PER_AT	0.196	6.953	0.131	3.711
Purchase cost	-0.048	-9.355	-0.062	-11.909
Travel cost	-0.034	-1.876	-0.055	-2.66
Parking cost	-0.042	-5.578	-0.008	-1.898
Shared Autonomous Vehicles on (Choice Model)				
Constant	-0.697	-13.365	-0.139	-2.411
PER_US	0.369	6.374	0.481	7.56
PER_AT	0.055	1.847	-0.014	-0.363
Travel cost	-0.018	-4.156	-0.029	-6.707
Membership cost	-0.225	-5.187	-0.301	-7.251

Goodness-of-fit Measures		
Initial LL	-328030.89	-336746.57
Final LL	-281343.13	-283396.33
Rho Squared value	0.14	0.16
AIC	562958.25	567064.67
BIC	563869.32	567976.73
Sample Size adjusted BIC	563437.15	567544.56

Note: We relate to the statements for the Likert scale questions by referring to the variable names presented in Table 2

6. Conclusions

Findings of our previous research carried out in Denmark (Baburajan et al., 2018) and India (Baburajan et al., 2021) indicates that open-ended questions when placed before the set of Likert scale questions, primes the responses of these Likert scale responses. In this study, we investigated this further using a larger dataset, which is also representative of the population of the USA. Research findings reinforce these findings, as we observe a significant reduction in the number of neutral responses; thereby reducing central tendency bias. Unfortunately, we do not have information and evidence to pinpoint the actual reason for this difference in behaviour. However, we hypothesise that respondents might have to pause, think, and articulate the response to answer the open-ended question, and this due process might have altered their thought process and response. Ideally, one could infer this based on the surveys' duration, but we could not observe a difference in the overall duration for answering questions on a page. And this could be because the overall duration might be influenced by device type to answer the survey and the internet speed- to name a few. Furthermore, it is difficult to comment on the accuracy of the SP experiments, as it is difficult to benchmark it with the actual behaviour; but it would be interesting to use a similar approach for Revealed-Preference surveys.

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