

When Neutral Responses on a Likert Scale Do Not Mean Opinion Neutrality: Accounting for Unsure Responses in a Hybrid Choice Modeling Framework

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ITM 2018

June, 25 2018





Outline

- Motivation
- Implications of Opinion Neutrality on Policy
- Case Study
- Methodology – ICLV Model
- Results
- Discussion and Future Work



The Likert Scale

- Psychometrically measure attitudes and perceptions in the surveys
- Uses a bi-polar symmetric scale, typically from some positive to some negative
- Generally, Likert scaling assumes that the distance between items are equal
- Scales with an odd-number of levels are common
 - On a continuum from one extreme to another extreme and thus the middle/neutral response acts as a transition point between the two polar options
 - Various labels used for middle option: 'Neither agree nor disagree', 'undecided', 'uncertain', 'not sure'
 - Despite the use of a variety of labels, this position indicates neutrality and is seen as equidistant in spatial terms from the points of agreement and disagreement



Likert Scale Example

How satisfied are you with the performance of USF's Civil and Environmental Engineering Department over the last year?

- Very Satisfied
- Satisfied
- Neither Satisfied nor Unsatisfied
- Unsatisfied
- Very Unsatisfied



Who Chooses the Middle Option?

- The neutral group of respondents who choose the middle option in a Likert scale is not homogeneous
- These respondents are not all truly opinion neutral and thus do not act as a transition group between these extremes (Kalton et al. 1980, Cacioppo et al. 1997, Baka et al. 2012, Sturgis et al. 2014)
- They fall into two groups:
 1. **[Opinion Neutrality]** Those individuals who possess true opinion neutrality on the issue
 2. **[No Opinion]** Those individuals having no opinion and without adequate knowledge



Who Chooses the Middle Option?

- Researchers did not highlight the process by which, and the conditions under which, a neutral position will shift the distribution of responses
- Studies have failed to find a clear relation between effect of sociodemographic characteristics on the neutral responses (Kalton et al. 1980)
- One study showed that respondents with low levels of education are more likely to choose this answer option suggesting that people are more likely to choose “no opinion” responses when they perceive the processes of producing an optimal response as cumbersome (Krosnick et al 2002)
- No significant difference in providing bipolar continuum with or without neutral opinion



An Effect on Policy and Forecasting?

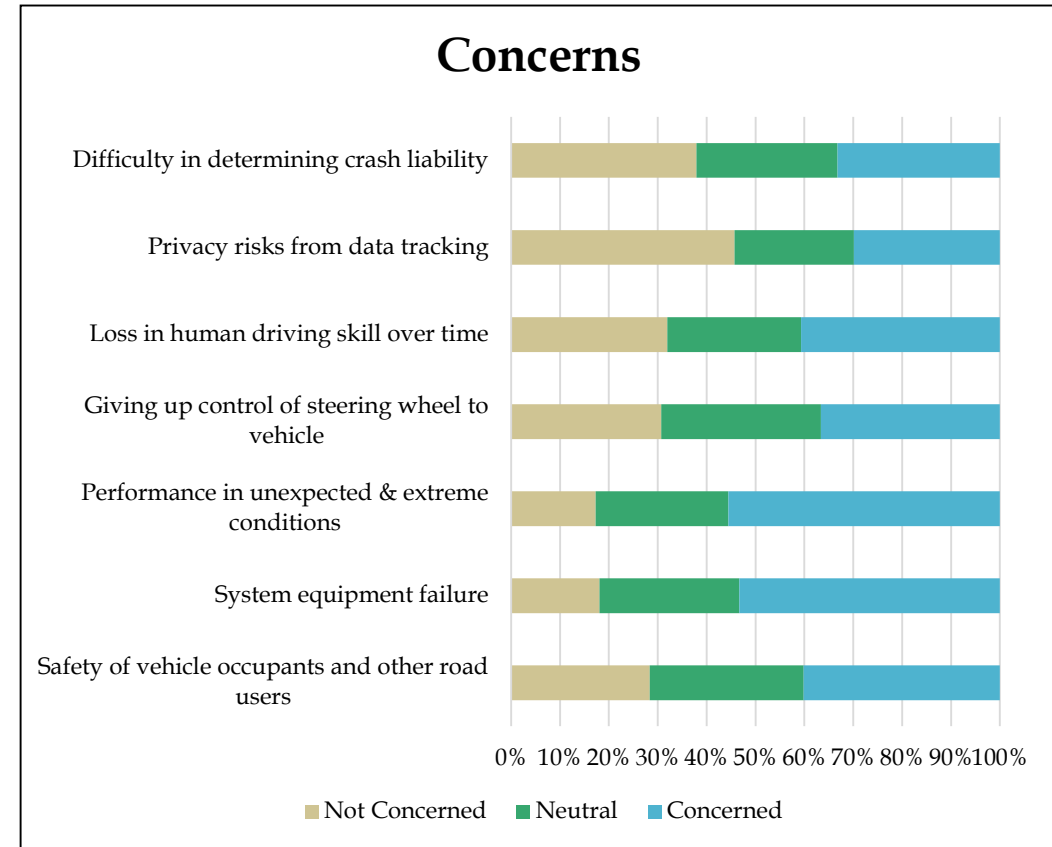
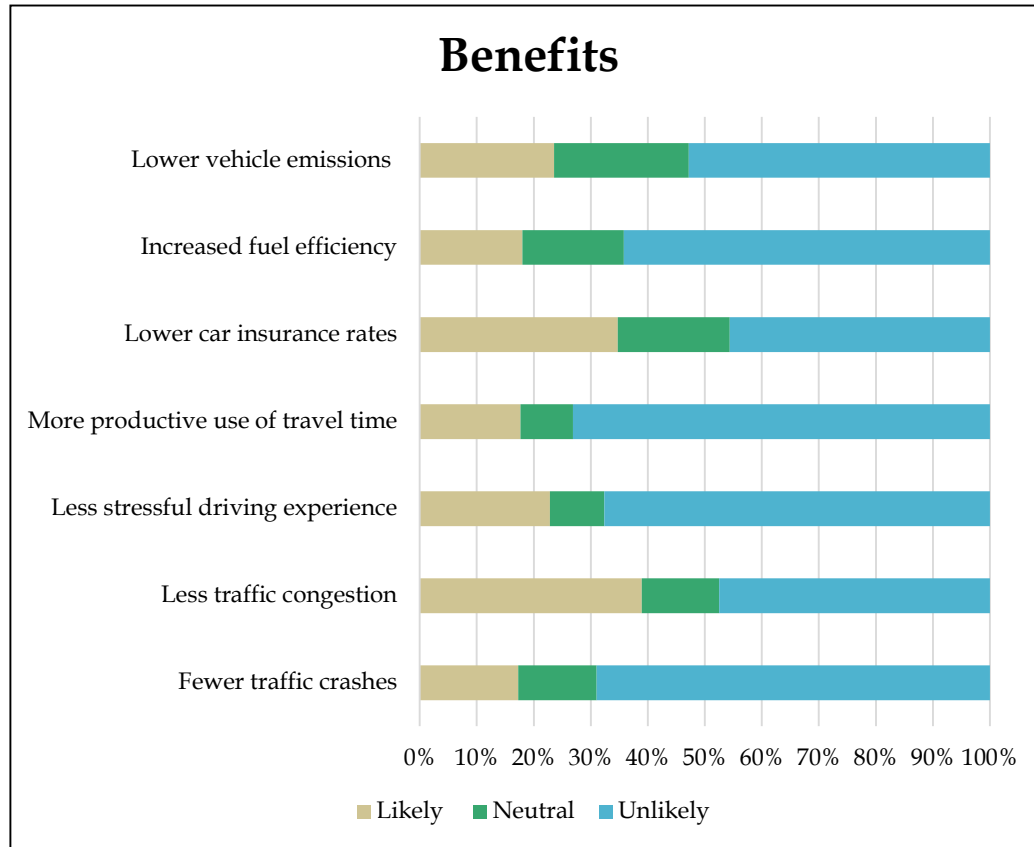
- Previous studies shows that the respondents choosing the neutral options fall into different categories
- Respondents with lack of knowledge will respond differently from people with no-opinion once they gather information
 - This temporal instability can effect the effects of policies formulated
- It is important to segregate them to formulate policies by avoiding biases in measurement
- Provides guidance on where to concentrate efforts in education for information campaigns



Case Study

- Survey designed to collect data on consumers' perception and intended adoption of autonomous vehicles (Menon 2015)
- Web-based survey with sample consisting of 2338 responses from AAA members regionally (primarily Southeast and Midwest)
- “What would be your most preferred way to use AVs that can fully drive by themselves without your involvement (when they become available)?”
 - Own (purchase or lease) AVs
 - Rent an AV as the need arises and use AVs as part of a service
 - Neither interested in investing in an AV nor using AVs as a transportation service

Distribution of Responses for AV Benefit and Concern Likert Scale Questions



Autonomous Vehicle Familiarity

- Ordered probit model for responses to :
 - “How familiar were you about Autonomous Vehicles (AVs) before you participated in this survey?” [4-point Likert scale: Not at all, Slightly, Moderately, Extremely familiar]

Variables	Estimate (t-stat)
Age	(-) 0.247 (1.98)
Respondents with college degree	(+) 0.273 (3.65)
Women	(-) 0.566 (9.95)
Household income	(+) 0.053 (3.95)
Respondents involved in a crash	(+) 0.211 (3.35)
People who drive alone to commute	(+) 0.327 (2.61)
Distance to commute	(+) 0.024 (2.30)



Familiarity and Neutrality

	Familiar	Unfamiliar
Neutral	(Opinion) Neutral Respondents	No-Opinion Respondents
Non-Neutral	Informed Opinionated Respondents	Uninformed Opinionated Respondents

Methodology: Integrated Choice and Latent Variable Model

$$U_n = Bx_n + \Gamma x_n^* + \varepsilon_n \quad (\text{choice utility equations})$$

$$x_n^* = Ax_n + v_n \quad (\text{latent variable structural equations})$$

$$i_n = Dx_n^* + \eta_n \quad (\text{latent variable measurement equations})$$

$$y_{nj} = \begin{cases} 1 & \text{if } u_{nj} > u_{nj'} \quad \forall j' \in \{1,2,3\} \\ 0 & \text{otherwise} \end{cases}$$

- $U_n \rightarrow (J \times 1)$ vector of utilities of each of J alternatives
- $x_n \rightarrow (K \times 1)$ vector of observable explanatory variables
- $x_n^* \rightarrow (M \times 1)$ vector of latent explanatory variables
- $B, \Gamma \rightarrow (J \times K)$ and $(J \times M)$ matrices of model parameters
- $\varepsilon_n \rightarrow (J \times 1)$ vector IID Gumbel error terms
- $A \rightarrow (M \times K)$ matrix of parameters denoting the relationship between the latent & observable variables

Model Specification: AV Usage Intent Choice Model

Assessment **Neutral** **No-Opinion** **Opinionated
Unfamiliar**

$$U_{n,own} = B_{own}x_n + b_{own,a} a_n^* + b_{own,t} t_n^* + b_{own,o} o_n^* + b_{own,p} p_n^* + \varepsilon_{own,n}$$

$$U_{n,rent} = B_{rent}x_n + b_{rent,a} a_n^* + b_{rent,t} t_n^* + b_{rent,o} o_n^* + b_{rent,p} p_n^* + \varepsilon_{rent,n}$$

$$U_{n,no AV} = 0$$



Model Specification: Latent Variable Structural Models

$$a_n^* = A_a x_n + v_{a,n} \quad (\text{assessment})$$

$$t_n^* = A_t x_n + v_{t,n} \quad (\text{neutral-type propensity})$$

$$o_n^* = A_o x_n + v_{o,n} \quad (\text{no-opinion type propensity})$$

$$p_n^* = A_p x_n + v_{p,n} \quad (\text{uninformed opinionated type propensity})$$



Model Specification: Indicators for Assessment and Neutrality/Familiarity Types

Benefit (7)	Concern (8)	Neutrality/Familiarity Types (1 + 15)
Fewer traffic crashes	Safety of vehicle occupants and other road users	Familiarity with AV technology
Less traffic congestion	System equipment failure	Middle responses from the Benefit & Concern perceptions (15)
Less stressful driving experience	Performance in unexpected and extreme conditions	
More productive use of travel time	Giving up control of steering wheel	
Lower car insurance rates	Loss in human driving skill over time	
Increased fuel efficiency	Privacy risks from data tracking	
Lower vehicle emissions	Difficulty in determining crash liability	
	Motion sickness	



Model Specification: Assessment Latent Variable Measurement Model

Indicators	Variable Type	Assessment
Level Chosen for Benefits Questions Extremely Unlikely (1) to Extremely Likely (5)	Binary Probit (7)	+
Level Chosen for Concerns Questions Not at all Concerned (1) to Extremely Concerned (5)	Binary Probit (8)	-

Model Specification: Neutrality/Familiarity Types Latent Variable Measurement Model

Indicators	Variable Type	Neutral Respondents	No-Opinion Respondents	Uninformed Opinionated Respondents
Middle Level Chosen for Benefits Questions $\mathbb{I}\{i_{benefit,q} = 3\}, \quad q \in \{1,2, \dots, 7\}$	Binary Probit (7)	+	+	-
Middle Level Chosen for Concerns Questions $\mathbb{I}\{i_{concern,r} = 3\}, \quad r \in \{1,2, \dots, 8\}$	Binary Probit (8)	+	+	-
Familiarity Response Not familiar (1) to Very Familiar (4)	Ordered Probit	+	-	-



Model Results: AV Usage Intent Choice Model

Parameter Name	Own Alternative	Rent/Service Alternative
Alternative Specific Constant	-0.12	0.20
Woman Respondent	-0.51	-0.47
Household Size		-0.07
ln(respondent's age)	-0.09	-0.20
Household income / \$25k	0.05	0.06
Most Recent Vehicle Purchased was New	0.24	-0.13
Assessment Latent Variable (LV)	1.20	0.85
Neutral Respondent LV	-0.18	0.09
No-Opinion Respondent LV		-0.22
Uninformed Opinionated Respondent LV	0.20	-0.35



Model Results: Assessment Latent Variable Structural Models

Parameter Name	Estimate
ln(respondent's age)	0.22
College Degree and (age \geq 25 yrs)	
Woman Respondent	-0.16
Respondent Involved in Auto Crash	0.25
Respondent's Commute Distance	-0.04



Model Results: Neutrality/Familiarity Types LV Structural Models

Parameter Name	Neutral Respondents	No-Opinion Respondents	Uninformed Opinionated Respondents
ln(respondent's age)	-0.07	-0.08	0.08
College Degree and (age >= 25 yrs)	-0.10	-0.21	0.12
Woman Respondent		0.10	
Household income / \$25k	-0.02	-0.03	0.01
Respondent Involved in Auto Crash		-0.12	
Respondent's Commute Mode is Auto	-0.05		0.08
Respondent's Commute Distance			



Summary: Neutrality/Familiarity Types

	FAMILIAR	UNFAMILIAR
NEUTRAL	(Opinion) Neutral Respondents	No-Opinion Respondents
	Younger	Younger
	Less College	Less College
	Lower Incomes	Women
	Non-Auto Commuters	Less Income
NON-NEUTRAL		Less Likely in Auto Crash
		Uninformed Opinionated Respondents
		Older
		More College
		Higher Incomes
	Auto Commuters	



Discussion

- Proposed a first-step in an ICLV framework for accounting for the difference between having opinion neutrality and no-opinion
- Framework needs a way of measuring familiarity with a topic
- Case study found that opinion neutral respondents had different intended AV usage than no-opinion respondents
- Unfamiliar respondents who picked the middle option were found to have less formal education – past research found this link as well



Future Work

- Formulation of the choice model refined
 - Currently just a linear-in-parameter form for the latent variables
 - May consider transformations and interactions with the assessment variable
- Work with more datasets
 - May consider explicit experiments comparing neutral option scales with the option of denoting no opinion / unsure
- Considering using a latent class structure with two formulations under consideration
 - Latent classes with indicators
 - Latent classes with familiarity and neutrality latent variables as class membership covariates



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Appendix





Model Results: AV Usage Intent Choice Model

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Household income / \$25k	0.05	0.06
Most Recent Vehicle Purchased was New	0.24	-0.13
Assessment Latent Variable (LV)	1.20	0.85
Neutral Respondent LV	-0.18	0.09
No-Opinion Respondent LV	0.04	-0.22
Uninformed Opinionated Respondent LV	0.20	-0.35



Model Results: Assessment Latent Variable Structural Models

Parameter Name	Estimate
ln(respondent's age)	0.22
College Degree and (age \geq 25 yrs)	-0.02
Woman Respondent	-0.16
Respondent Involved in Auto Crash	0.25
Respondent's Commute Distance	-0.04



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ln(respondent's age)	-0.07	-0.08	0.08
College Degree and (age >= 25 yrs)	-0.10	-0.21	0.12
Woman Respondent	0.00	0.10	-0.04
Household income / \$25k	-0.02	-0.03	0.01
Respondent Involved in Auto Crash	-0.03	-0.12	-0.01
Respondent's Commute Mode is Auto	-0.05	-0.06	0.08
Respondent's Commute Distance	-0.00	-0.00	0.00