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How to Effectively Communicate about Greenhouse Gas Emissions with Different Populations

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ABSTRACT

A critical aspect of climate policy is effective communication about greenhouse gas emissions (GHG-E) themselves. However, since attitudes towards climate change vary by different segments of the population, different methods of communication about GHG-E may be necessary. This study investigates different responses to GHG-E information by population and how to best communicate such information with them. Eight framing techniques following goal framing theory and moral foundations theory were developed, and a discrete choice experiment was applied to determine willingness to pay (WTP) for CO_2 emissions reductions. Six segmentation analyses for people's WTP for emissions under different framing techniques were carried out for culture, region, urban-rural residence, political leaning, attitudes and beliefs towards climate change, and income. Based on the data of 2,015 respondents from six provinces of Canada, the strength of GHG information influence was tested according to different respondent segmentations. The results show that in most cases, an emoticon framing has the strongest influence, though two exceptions exist: With respect to political orientation, nearly all framings were ineffective for those on the extremes, and for those on the right (not extreme) the current label has the largest impact; With respect to climate change motivation, color framing works best for those unsure how to reduce emissions, while the current label works for those uninterested in reducing their emissions. Surprisingly, "tree" framing was most effective among those who report not being concerned about climate change. The results help policy and decision-makers improve the likelihood of climate-friendly choices being made.

Keywords: Greenhouse gas emissions, Framing technique, Vehicle purchasing decisions, Segmentation analysis, Willingness to pay (WTP), Climate Change Stage of Change (CC-SoC)

1. INTRODUCTION

The need to reduce carbon emissions is increasingly evident in addressing the problem of climate change (Grubb et al., 2022). Canadians understand that global warming is an urgent problem to be solved, and in 2015 the government set a goal for greenhouse gas (GHG) emissions reduction by 30% less than 2005 levels by 2030 (Canada, 2016). In July 2021, that target was modified to reductions of 40-45 %. However, support for government actions on climate change and willingness to pay (WTP) to reduce emissions varies by province (Mildenberger et al., 2016). Other research on climate change in the US has shown that climate concern and support for action varies according to individual characteristics such as political leaning (McCright et al., 2016a). Research on how people respond to information on climate change emissions has shown that some individuals are willing to pay more than others, and that this willingness to pay can relate to environmental attitudes (Waygood et al., 2021a). It is important to know these differences so that the impacts of policies on climate change can be better estimated. Further, since *how* information is presented can influence reactions (Wang et al., 2021), it is also important to know which methods work best with those different population groups (Creutzig et al., 2022).

Emissions from motorized vehicles are a major source of greenhouse gas emissions (GHG-E) that could be reduced through more efficient vehicle choices. As the International Panel on Climate Change (IPCC) reports, mobility choices are one of the most consequential decision in terms of individual climate change emissions (Creutzig et al., 2022). With respect to the Avoid-Shift-Improve mitigation strategies, a shift to more emissions-efficient vehicles would be an Improve strategy and a shift from internal combustion (gas) vehicles to battery-electric vehicles is highlight as the most effective shift option for individuals to reduce their emissions by the IPCC (Creutzig et al., 2022). Many developed countries present information about emissions of new vehicles to attract drivers to select fuel-efficient vehicles, such as the Environmental Protection Agency (EPA; (Agency, 2018)) label in the United States and the Natural Resources Canada (NRCan; (NRCan, 2019)) label in Canada. Labels shown on new vehicles provide information for consumers about vehicle emissions, typically with respect to the performance of other vehicles. The problem with this is that it does not present the information with respect to the government's

objectives of reducing emissions. They merely tell the individuals how performance relates to other similar products or requires the individual to do a number of calculations to understand how vehicles perform in an absolute sense.

Some research suggests that emissions information for transport decisions only influences environmentally motivated individuals (Gaker and Walker, 2013), but this may be related to *how* information is presented (Waygood and Avineri, 2011). Recent work by this research team has demonstrated that even climate-change "doubters" are influenced (measured as a willingness to pay) if the information is presented (framed) following theories of psychology (Daziano et al., 2021; Waygood et al., 2021a). However, differences can be seen by language and region (Wang et al., 2021) and it is important to develop information that appeals to different values and population demographics (Creutzig et al., 2022). Therefore, this study attempts *to examine how various framings of GHG emissions information affect WTP for GHG-E reductions for different population segments.* The research will examine the influence of such labels on new-vehicle labels as that is the only place currently in Canada where such information is commonly found for large-impact choices.

2. BACKGROUND

It is essential to know how different parts of the population respond to different types of framing so that the strength of climate change communication might be estimated for different population groups. The following summarizes research on how different groups respond to, or hold different motivations towards, climate change.

2.1 Culture

Different cultures have different values, and this may affect how they respond to emissions information, or how it is presented (Creutzig et al., 2022). Schwartz (Schwartz, 2004) proposed a theory of types of cultural value orientations. The theory posits that three pairs of opposing values reflecting critical issues found in every society across the globe; there are seven measures in total as one value is separated into two distinct parts. It is not a measure for individuals, it is a measure for society. Within Canada, numerous cultures exist,

of which the two dominant ones are French and English. These two cultures, though similar, have distinct measures (Schwartz, 2008). Of those three values, the Harmony-Mastery values are likely most relevant here.

The pair of Harmony and Mastery is concerned with society's relationship with the natural and social world. Harmony aims at a peaceful integration of the members of a society into both the natural and social world (e.g., protection of the environment). On the contrary, mastery promotes active self-assertion to control and change natural and social environments to reach individuals' or social goals (Schwartz, 2004). In Canada, French Canadians score higher on the Harmony scale than English Canadians (Schwartz, 2008). Moreover, English Canadians score higher on the Mastery scale than French Canadians. Since Harmony emphasizes the importance for a society to fit into its natural world, this result suggests that French Canadians might be more concerned about the environment and climate change than English Canadians.

2.2 Region

Belief in climate change in Canada is strong. National data (from https://www.umontreal.ca/climat/) reveals that, on average, 83% of Canadians believe the Earth is getting warmer and 60% of them believe this is due to human activity. Yet, although a majority of the population in each province reports believing in climate change, considerable variations are found between the provinces. Some populations have a lower than the average belief that climate change is anthropogenic. For example, in the three prairie provinces, Alberta (42 %), Saskatchewan (47 %), and Manitoba (57%) the population is likely to believe that the warming is anthropogenic. In contrast, the three largest provinces Ontario, Quebec, and British Columbia have belief levels of 60%, 67%, and 61% respectively, with Quebec having the highest level. This suggests that motivations might differ considerably between those groups of provinces.

2.3 Urbanization

Past research has generally, but not systematically, found that urban residents had greater environmental concerns than rural residents (Jones and Dunlap, 1992; Lowe and Pinhey, 1982; Vanliere and Dunlap, 1980). Some hypotheses have been proposed to explain why urban residents might be more concerned about the

environment than rural residents. Whereas urbanites are directly in contact with pollution and environmental deteriorations, rural residents are resource-dependent and have a utilitarian orientation toward the natural world. However more recently in Canada, Kennedy et al. (2009) found few differences between rural and urban residents on environmental concerns, when a wide array of behaviors were considered. In that study, rural residents placed a higher priority on the environment and reported higher participation in recycling and stewardship behavior. Finally, on climate change, research has found that urban areas across the country show stronger beliefs in climate change than in rural Canada (Mildenberger et al., 2016). Support for increasing taxes on carbon-based fuels appear also much lower in rural than urban areas in Canada (see: https://www.umontreal.ca/climat/). As such, related to climate change, urban residents might have a stronger reaction, but general environmental stewardship framings might be more effective for rural residents.

2.4 Politics

Political views have been linked to climate change belief and support for policies (McCright et al., 2016a). Generally, Conservatives (or the right) show fewer concerns for the environment and climate change than Liberals (or the left) (ibid). The Moral Foundation Theory (MFT) is one theory that has been linked with political views (Graham et al., 2009). It posits that five universal systems constitute the basis of individuals' moral preoccupations and judgments. These systems are the Harm/care, the Fairness/reciprocity, the Ingroup/loyalty, the Authority/respect, and the Purity/sanctity foundations (Haidt and Joseph, 2007). The first two are often referred to as the *individualizing foundations*, since they are concerned with one's well-being and autonomy, whereas the last three are known as the *binding foundations*. Research in the US has found that conservatives rely more equally on all five moral foundations to make moral judgments, Liberals rely more solely on the Harm/Care and Fairness/reciprocity foundations (Graham et al., 2009). Research has found that public discourses on environmental issues are mostly embedded into the Harm/Care foundation, which Liberals are more concerned about, but it does not resonate with Conservatives (Feinberg and Willer, 2013). That research suggested that GHG emissions information framed with the binding

foundations (e.g., Purity/sanctity, Ingroup/loyalty) might have a greater influence on right-leaning individuals (in a Canadian context).

2.5 Climate change concern

People's attitudes or beliefs towards climate change could be represented by a simple indicator of Climate Change Stage of Change (CC-SoC) and this relates strongly to the strength of response to GHG-E information (Wang et al., 2021; Waygood et al., 2021b). This is not unexpected, but it is important to know how reactions to different framings of the information differ among those groups (Creutzig et al., 2022). Previous research has shown that WTP varies by an individual's Climate Change Stage of Change, but the results presented relate to population averages, and it is not clear how the response to different framings varies. For example, framing with respect to environmental objectives might be very effective for those who are climate-change motivated, but it may be less effective for those unconcerned.

2.6 Income

A review of influences on measures of climate change found that income is not likely related to belief in, concern for, actions related to, or policy on climate change (McCright et al., 2016b). However, in the context of being able to pay for a technology that costs more, higher incomes are likely related to an ability to pay which can be related to the likelihood of adopting "Improve" mitigation strategies (Creutzig et al., 2022). As such, it is anticipated that individuals at higher incomes will be more likely to choose the costlier environmental choices.

3. METHODOLOGY

3.1 Survey

Since the attitude and support for government actions on climate change vary by province in Canada, this study selected a pan-Canadian sample of provinces to conduct the survey. In particular, respondents were selected from British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec representing over 90 % of the population in Canada. Only driving license holders aged 18 years old or over could complete the survey as it related to purchasing a car. Since the majority of Quebec residents are francophones, the survey was carried out in two languages: English and French. A larger sample was gathered from Quebec

(1,200) since the project was funded by the Quebec Government and greater detail was required for that population. Previous research included respondents from Saskatchewan and Alberta as they are the most likely to not support government action on climate change (Wang et al., 2021), Manitoba was added as it had a mix of such beliefs. British Columbia was included as a large population center and a population that is more likely to believe that the Earth is getting warmer as a result of human activity (Mildenberger et al., 2016). Ontario was added as it is the largest population center in Canada. The responses were collected in June, 2021 by SurveyEngine, a discrete choice experiment survey and recruitment company.

After data cleaning, data from 2,015 respondents were used in the analysis, including 750 French speakers (37%) and 1,265 English speakers (63%) in the sample. Select attributes of the respondents are shown in **TABLE 1**. Different segmentation variables are shown in **TABLE 2** according to respondent language, region (province), urban-rural residence, political leaning, and Climate Change Stage of Change (CC-SoC). The results of chi-squared analyses showed that the choices towards different types of vehicles are statistically different between different subsamples (p=0.000).

TABLE 1 Attributes characteristics of the respondents at individual and household levels

Variable	Freq.	Percent	Cum.
Gender			
Male	970	48.14	48.14
Female	1042	51.71	99.85
Other	3	0.15	100.00
Age			
19-29	309	15.33	15.33
30-39	345	17.12	32.46
40-49	422	20.94	53.40
50-59	470	23.33	76.72
60+	469	23.28	100.00
Employment			
Full-time	1094	54.29	54.29
Part-time	195	9.68	63.97
Homemaker	75	3.72	67.69
Student	98	4.86	72.56
Other	553	27.44	100.00
Education attainment			
High school or lower	413	20.50	20.50
Trade	165	8.19	28.68
College	542	26.90	55.58

University	656	32.56	88.14
Postgraduate	239	11.86	100.00
Ethnicity*			
European, North American, and Other North American origins	1593	79.06	79.06
BIPOC	306	15.19	94.24
Prefer not to answer	116	5.76	100.00
Currently own a vehicle			
Yes	1821	90.37	90.37
No	194	9.63	100.00
Household income			
Less than C$30,000	213	10.57	10.57
C$30,000-C$49,999	269	13.35	23.92
C$50,000-C$74,999	373	18.51	42.43
C$75,000-C$99,999	332	16.48	58.91
C$100,000 or more	610	30.27	89.18
Prefer not to answer	218	10.82	100.00

TABLE 2 Segmentation variables

Variable	Freq.	Percent	Cum.
Language			
English	1265	62.78	62.78
French	750	37.22	100.00
Province			
Alberta	258	12.80	12.80
British Columbia	257	12.75	25.55
Manitoba	142	7.05	32.60
Ontario	258	12.80	45.40
Quebec	977	48.49	93.89
Saskatchewan	123	6.10	100.00
Urban-Rural Residence			
Urban	1789	88.78	88.78
Rural	226	11.22	100.00
Political spectrum			
Extreme Left	104	5.16	5.16
Left	352	17.47	22.63
Neutral	832	41.29	63.92
Right	279	13.85	77.77
Extreme Right	66	3.28	81.04
Prefer not to answer	382	18.96	100.00
Climate Change Stage of Change			
CC-SoC stage 1	222	11.02	11.02
CC-SoC stage 2	259	12.85	23.87
CC-SoC stage 3	387	19.21	43.08
CC-SoC stage 4	728	36.13	79.21
CC-SoC stage 5	419	20.79	100.00

*For more details about the ethnicity questions, please visit https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

The measure of CC-SoC represents the individual's concern about climate change and behavior. It was inspired from Transtheoretical Model (Prochaska et al., 2015; Waygood et al., 2021b). Individuals self-identified which of the following five stages most closely characterized them.

1) CC-SoC stage 1: I am not concerned about climate change;

2) CC-SoC stage 2: I am concerned about climate change, but I won't reduce emissions;

3) CC-SoC stage 3: I am concerned about climate change, but I don't know what to do;

4) CC-SoC stage 4: I am concerned about climate change, and will reduce emissions in the future;

5) CC-SoC stage 5: I am concerned about climate change, and I have already reduced my emissions.

3.2 Discrete choice experiment

The influence of the GHG-E information can be inferred from people's vehicle purchasing decisions. In this study, a Discrete Choice Experiment (DCE) was administered to investigate people's preferences of vehicle choice based on car labels. For the DCE design, four attributes were considered in the utility function (TABLE 3): CO_2 emissions, fuel costs, purchase price, and electric vehicle range. Three alternative vehicle types were labeled as a Gasoline Vehicle (GAS), Plug-in Hybrid Electric Vehicle (PHEV), and Battery Electric Vehicle (BEV). Total annual emissions were calculated in grams of CO_2 per kilometer for each vehicle type based on an annual distance of 20,000 km employed by NRCan to estimate fuel costs. That amount was used to calculate monthly emissions.

In the current investigation, a D-efficient design in Ngene is adopted (ChoiceMetrics, 2018) for the discrete choice experiment, and prior information for the variables is based on the research results of Wang et al. (Wang et al., 2021), which has the same experimental design and precise econometric model.

TABLE 3 Attributes levels for different vehicle types

Alternatives	**Price (C$)**	**Monthly fuel cost (C$)**	**CO_2 emissions (kg/month)**	**Range electric (km)**
GAS	[17,000; 20,000; 27,000]	[100; 170; 210]	[200; 300; 400]	——
PHEV	[33,000; 38,000]	[55; 62]	[50; 80]	[40; 90]

BEV	[42,000; 48,000]	[30; 40]	——	[150; 240; 430]

3.3 GHG Framings

To make the new label applicable to real-life situations, CO_2 emission formats were adjusted based on the current NRCan label. Eight framings are used in this research (see **Figure 1; TABLE 4**).

TABLE 4 The reason for using each framing in this experiment

	Framing	Reason for testing	Details
1	NRCan label	The current label used by Natural Resource Canada; acting as a reference.	Vehicles are grouped into 10 categories that relate only to other vehicles, and not to any limit or reduction target.
2	Hedonic framing	Previously found to be the most influential (Wang et al., 2021); color is used to link with emotions: blue for calm, red for angry.	Presenting CO_2 information with a 30% reduction target of 2005 levels + C$50/tonne carbon tax integrated into fuel costs + color is used for the CO_2 information (for more details, please see Wang et al., 2021). Blue for anything that is better than target, red for anything that is worse.
3	Pressure gauge	This is a graphic representation as focus groups and general feedback suggested that the wording used in (2) could be confusing.	Presenting CO_2 information with CO_2 emissions (g/km) + C$50/tonne carbon tax integrated into fuel costs + pressure gauge.
4	New emojis	This combined hedonic information (color), injunctive norms (emojis; (Schultz et al., 2007)), and air quality (coughing; (Feinberg and Willer, 2013)).	Presenting CO_2 information with a 30% reduction target of 2005 levels + C$50/tonne carbon tax integrated into fuel costs + new emojis.
5	Patriotic/steps	The addition of a maple leaf was used to imply patriotism, linked to the Moral Foundations Theory. The steps imply some effort is required to reach the goal. This moral foundation is typically stronger in more central-right individuals. (Feinberg and Willer, 2013)	Presenting CO_2 information with CO_2 emissions (g/km) + C$50/tonne carbon tax integrated into fuel costs + patriotic goal framing
6	Dirty air	Individuals on the right have previously been found to respond stronger to local air quality issues (impurity), than to a global commons problem (equity) (Feinberg and Willer, 2013)	Presenting CO_2 information with CO_2 emissions (g/km) + C$50/tonne carbon tax integrated into fuel costs + dirty air scale
7	Trees	This framing is related to environmental stewardship and the link between trees and the environment. (Boykoff, 2009)	Presenting CO_2 information with CO_2 emissions (g/km) + C$50/tonne carbon tax integrated into fuel costs + tree scale

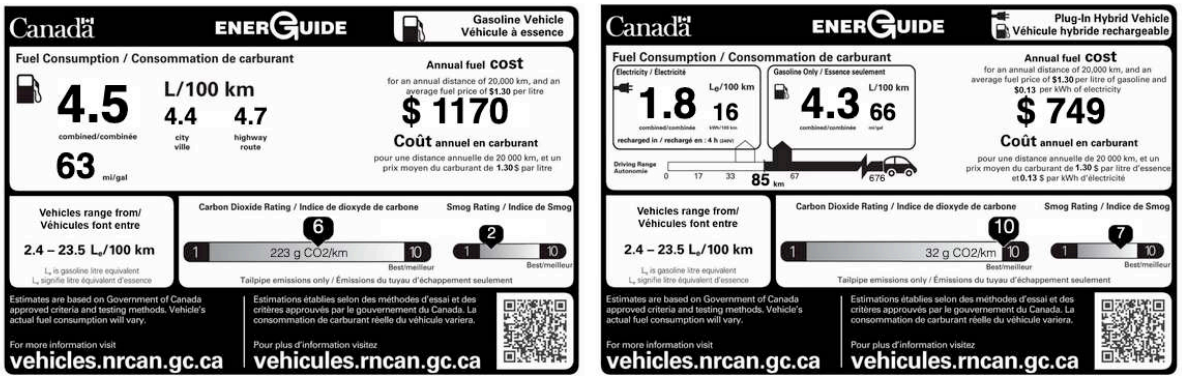
8	Injunctive norm	The thumbs up/thumbs down are used to project a "societal approval" linked to injunctive norms.	Presenting CO_2 information with 30% reduction target of 2005 levels + C$50/tonne carbon tax integrated into fuel costs + thumbs up/down

Among the eight treatments, treatment 1 is the current NRCan label, and treatment 2 is the best frame with the highest willingness to pay for CO_2 reductions based on our previous research (Wang et al., 2021). The others are new and their reasons for inclusion are given here with further details in the background section. In order to connect the treatment information with different vehicle types in the experiment (see **TABLE 3**), **TABLE 5** provides the details on framings and emissions per vehicle in the experiment.

TABLE 5 Details on framings and emissions per vehicle in the experiment

Motor type	**BEV**	**PHEV**	**PHEV**	**ICEV**	**ICEV**	**ICEV**
Grams of CO_2 per km	0	32	49	106	186	223
% of target	100 % better	64 % better	44 % better	21 % worse	112 % worse	154 % worse
NRCan (grams)	10	10	10	10	7	6
Hedonic (%)	Blue text	Blue text	Blue text	Red text	Red text	Red text
Pressure gauge (%)	0/18, blue	3/18, blue	5/18, blue	11/18, yellow	17/18, red	over 18/18, red
New emojis	Blue smiley face with thumbs up	Green smiley face	Green smiley face	Yellow neutral face	Orange frowning face	Red coughing face
Patriotic goal (grams)	5th (top) step, celebrating	4th step, stepping up	4th step, standing	2nd step, looking up	2nd step, stepping down	1st (bottom) step, pointing up
Dirty air (grams)	Complete right, blue and clear	3/18, blue sky	5/18, blue sky	11/18, some smoke	17/18, dark smoke	Complete left, dark smoke
Tree (grams)	Full and green	Lots of leaves on each branch	Multiple leaves on each branch	A few leaves on each branch	One leaf per branch	No leaves (dead)
Thumbs up/down (%)	Two thumbs up	One thumb up	One thumb up	One thumb down	Two thumbs down	Two thumbs down

One framing treatment is randomly assigned to each respondent, and they need to complete 12 choice tasks. **Figure 1** shows one example of a choice task for each framing technique. As the information can get quite small and the framings hard to see when the images are small as in this article, respondents were required to complete the survey on a computer where they could click on the image to further enlarge it.



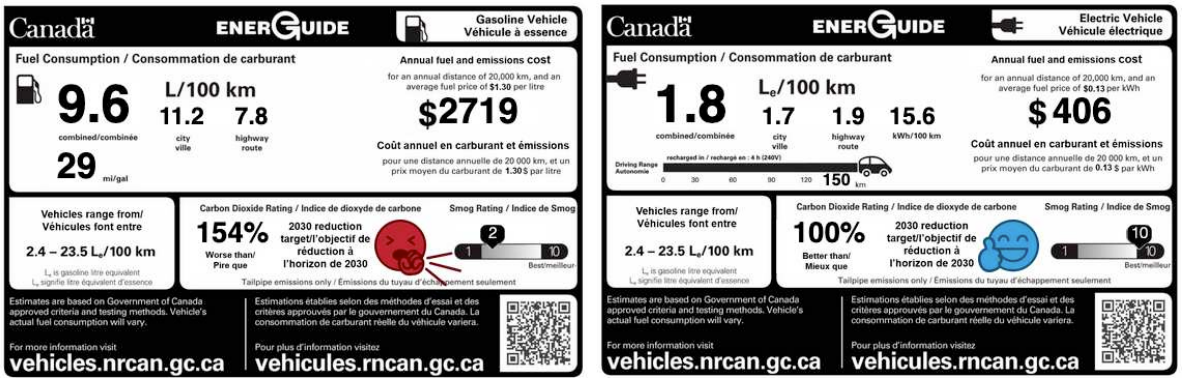
(a) NRCan label and vehicle choice



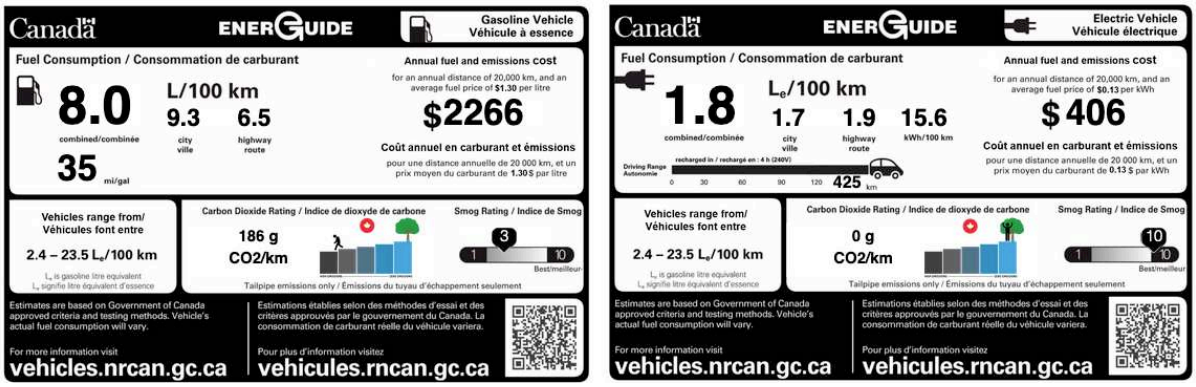
(b) -30% societal goal with color label and vehicle choice



(c) Pressure gauge label and vehicle choice



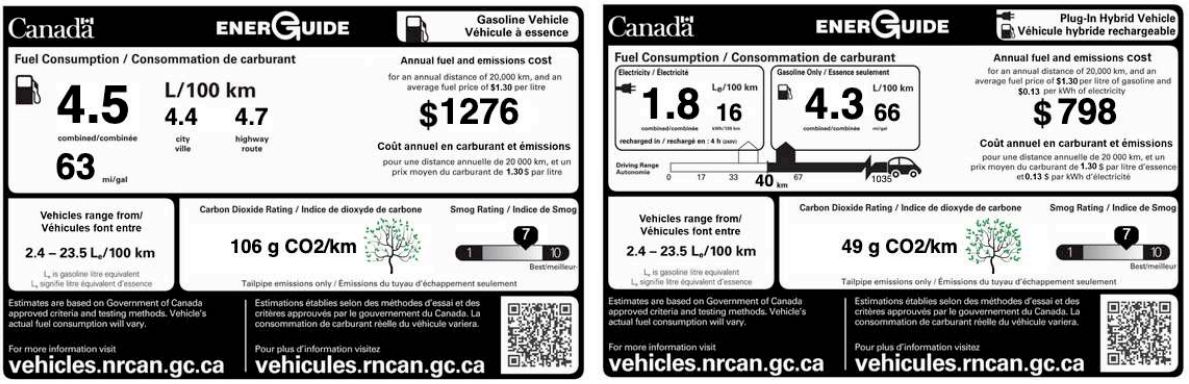
(d) -30% societal goal with new emoticon label and vehicle choice



(e) Patriotic goal label and vehicle choice



(f) Dirty air label and vehicle choice



(g) Tree scale label and vehicle choice



(h) -30% societal goal with thumbs up/down label and vehicle choice

Figure 1 New NRCan vehicle labels with different framing techniques examined in this study

3.4 WTP space model

A WTP space model is constructed in which the taste parameters directly denote the WTP. Even though WTP estimates can be derived from a marginal rate of substitution coming from the ratio of marginal utilities, working in WTP-space provides direct inference on the desired metric of interest while avoiding the technical problems associated with working with parameter ratios (Hensher and Greene, 2011; Hensher et al., 2015). Moreover, the WTP for marginal emissions reduction is the most direct metric to measure and compare the influence of the GHG emissions on the stated choices (Daziano et al., 2017; Wang et al., 2021). The utility function is:

$$U_{ij} = ASC_j + \alpha P_{ij} + \frac{\alpha}{r}[C_{ij} + (\omega_E + \sum_{k=1}^{6} \delta_k treat_{ik})E_{ij}] - \alpha\omega_R R_{ij} + \varepsilon_{ij} \quad (1)$$

Where ASC_j is the alternative specific constant of vehicle j which represents the individual's preference for different vehicle types. P_{ij} is purchase price, C_{ij} is a monthly uniform equivalent operating costs, $treat_{ik}$ is a binary variable for treatment k ($k = 1$ is the current label in Canada, which acts as the reference), E_{ij} is a monthly uniform equivalent emission, and R_{ij} is the electric driving range for PHEV or BEV j. Electric vehicle range and purchase price are properties of the vehicles, so they are not (future) discounted. α is the scale parameter, and r is a monthly subjective discount rate that allows for direct comparison of future and currents generalized costs (Allcott and Wozny, 2014). ω_E is the WTP for marginal reductions in emissions of CO_2 equivalent, and ω_R is the WTP for a marginal improvement in electric driving range. Here the ω_E is the basic reference of the WTP for CO_2 emissions, and δ_k is the marginal WTP for emissions reduction caused by treatment effects. The total WTP for emission savings is the superimposed effects of the basic reference of the WTP for CO_2 emissions and the treatment effects (framings). The unit will be changed to C$/tonne finally.

4 RESULTS AND ANALYSIS

4.1 Culture

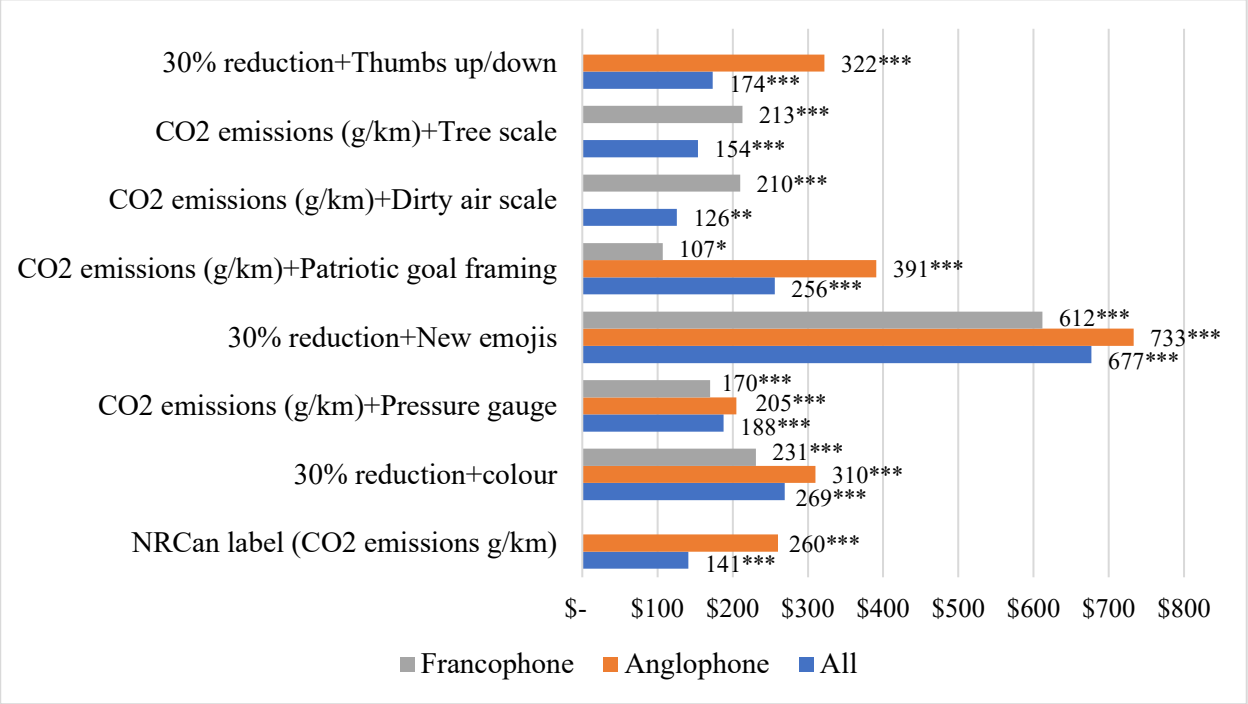
In this subsection, culture is assumed to relate to the language by which the respondent completed the survey. **TABLE 6** shows the marginal effects of the alternative framings compared with the NRCan label. In both cases, the addition of the emoticon was the strongest framing. The weakest framings for English respondents were the Dirty air scale and the Tree scale which both have significant negative marginal effects on the WTP. Whereas, for the French, there were two framings that didn't have significant influence on WTP compared with the current NRCan label: the Patriotic one and the Thumbs up/down one. This difference may be due to presenting different information about climate change by English and French media in Canada (Young and Dugas, 2012). Hence, different cultures should be considered in selecting an optimal framing, though the new framing (emoticon) is highly qualified to increase WTP for both cultures.

TABLE 6 Segmentation analysis with language (used as a proxy for culture)

Name	Total		English		French	
	Estimate		Estimate		Estimate	
ASC-BEV (ref.)	0		0		0	
ASC-GAS	-0.0129		0.0145		-0.057	
ASC-PHEV	0.33	***	0.271	***	0.443	***
Price (10,000 C$)	-0.686	***	-0.646	***	-0.762	***
Discount rate (r) (monthly)	0.0171	***	0.0192	***	0.0148	***
Range (km)	8.27	***	5.82	*	12.5	***
Reference WTP for CO_2 (kg per month)	0.141	***	0.26	***	0.00882	
NRCan label (ref.)	0		0		0	
30% reduction + Color	0.128	***	0.05		0.222	***
CO_2 emissions (g/km) + Pressure gauge	0.0468		-0.0552		0.161	**
30% reduction + New emoticons	0.536	***	0.473	***	0.603	***
CO_2 emissions (g/km) + Patriotic goal framing	0.115	**	0.131	*	0.0981	
CO_2 emissions (g/km) + Dirty air scale	-0.0151		-0.208	***	0.201	***
CO_2 emissions (g/km) + Tree scale	0.0128		-0.162	**	0.204	***
30% objective + carbon tax + Thumbs up/down	0.0325		0.0621		-0.000342	
Estimation report						
Number of estimated parameters	13		13		13	
Sample size	24180		15180		9000	
Init log likelihood	-16760.3		-10521.97		-6238.325	
Final log likelihood	-15710.43		-9818.687		-5817.538	
LR-Test (full model)	2099.747		1406.574		841.5725	
Rho-square for the init. Model	0.0626		0.0668		0.0675	
Rho-square-bar for the init. Model	0.0619		0.0656		0.0654	
Akaike Information Criterion	31446.85		19663.37		11661.08	
Bayesian Information Criterion	31552.06		19762.54		11753.44	
Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.						

The total WTP under different framings is calculated by combining the basic reference of WTP for CO_2 with the marginal WTP by treatment effects, see **Figure 2**. For example, the reference of WTP for CO_2

for Anglophone is C$0.26/kg, and the treatment effect of Pressure gauge has a very weak marginal effect on WTP of C$-0.0052/kg (not significantly different from 0, i.e., NRCan label). So, the total WTP of the pressure gauge effect is -0.0552 + 0.26 = C$0.2048/kg. Changing the unit to C$/tonne will result in C$205/tonne (rounded integer). According to the properties of expectation and variance of two-dimensional random vector sums, as well as the significance calculation formula, the superimposed effect of the Pressure gauge for the Anglophone is significant, shown in **Figure 2**. That means the significance of the same treatment can be different between the marginal effects and the total effects.



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 2 Willingness to pay for tonnes of CO_2 under different framings for Anglophone and Francophone (only significant findings are displayed)

4.2 Region

As mentioned in the background, belief in climate change and support for government action vary by province in Canada. Analysis was first run with each province, but results were not significantly different between a couple of neighboring provinces, so these were combined (see **TABLE 7**). The total WTP results for different regions can be seen in **Figure 3**. The only region where the overall influence of the current

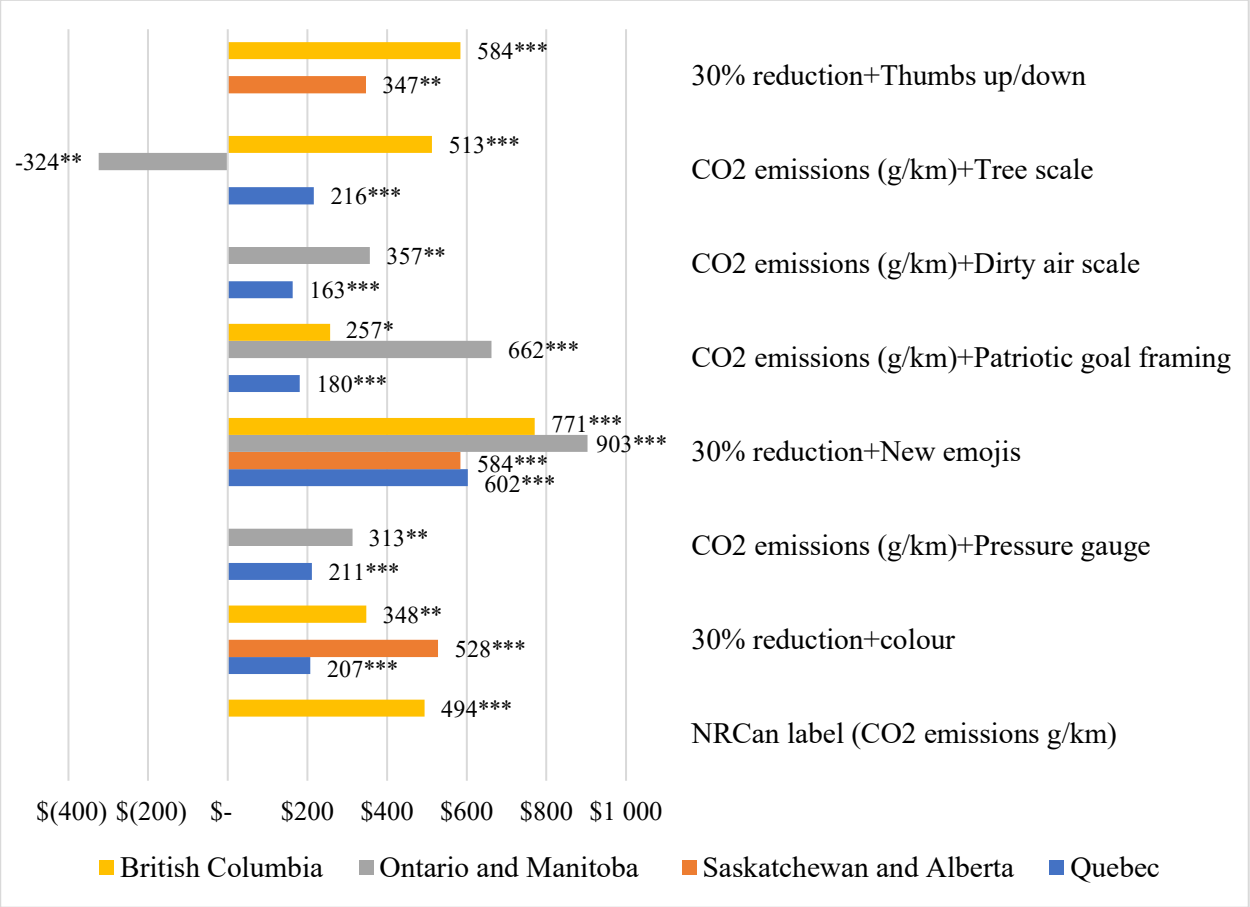
NRCan label is significant is British Columbia (B.C.). In all regions, the emoticon was the most effective again. Differences can be seen in what was the least effective. For Quebec, the Thumbs up/down label was the weakest. In Saskatchewan and Alberta, the Dirty air scale and the Tree scale actually caused negative WTP. For Manitoba and Ontario, the Tree scale also resulted in a negative WTP. In B.C., the Dirty air scale resulted in a negative WTP. For the best performing framing (i.e., new emojis), Manitoba + Ontario has the highest WTP for CO_2 reductions, followed by B.C., Quebec, and finally Saskatchewan + Alberta. As such, the overall trend where Alberta and Saskatchewan have lower WTP is in line with their lower belief that the climate crisis is human caused. It should be noted that despite that, the emoticon was found to increase WTP.

TABLE 7 Segmentation Analysis with Region

	Quebec (English and French)		Saskatchewan + Alberta		Manitoba + Ontario		British Columbia	
Name	Estimate		Estimate		Estimate		Estimate	
ASC-BEV (ref.)	0		0		0		0	
ASC-GAS	-0.0657		0.081		0.067		-0.208	
ASC-PHEV	0.412	***	0.201	*	0.312	***	0.227	*
Price (10,000 C$)	-0.716	***	-0.662	***	-0.715	***	-0.666	***
Discount rate (r) (monthly)	0.0154	***	0.0212	***	0.0198	***	0.0171	***
Range (km)	11.6	***	1.63		10.1	*	-0.00822	
Reference WTP for CO_2 (kg per month)	0.0403		0.251		0.135		0.494	***
NRCan label (ref.)	0		0		0		0	
30% reduction + Color	0.167	***	0.277	*	0.0694		-0.146	
CO_2 emissions (g/km) + Pressure gauge	0.171	***	-0.228		0.178		-0.313	**
30% reduction + New emoticons	0.562	***	0.333	**	0.768	***	0.277	*
CO_2 emissions (g/km) + Patriotic goal framing	0.14	**	-0.262		0.527	***	-0.237	*
CO_2 emissions (g/km) + Dirty air scale	0.123	**	-0.329	*	0.222	*	-0.598	***
CO_2 emissions (g/km) + Tree scale	0.176	***	-0.313	*	-0.459	***	0.0189	
30% objective + carbon tax + Thumbs up/down	-0.0226		0.0962		0.0701		0.0902	
Estimation report								
Number of estimated parameters	13		13		13		13	

Sample size	11724	4572	4800	3084
Init log likelihood	-8126.458	-3169.069	-3327.106	-2137.666
Final log likelihood	-7638.539	-2804.493	-3038.833	-2018.054
LR-Test (full model)	975.8365	729.1511	576.546	239.2237
Rho-square for the init. Model	0.06	0.115	0.0866	0.056
Rho-square-bar for the init. Model	0.0584	0.111	0.0827	0.0499
Akaike Information Criterion	15303.08	5634.987	6103.667	4062.108
Bayesian Information Criterion	15398.88	5718.547	6187.86	4140.55

Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 3 Willingness to pay for tonnes of CO_2 under different framings for different regions (only significant findings are displayed)

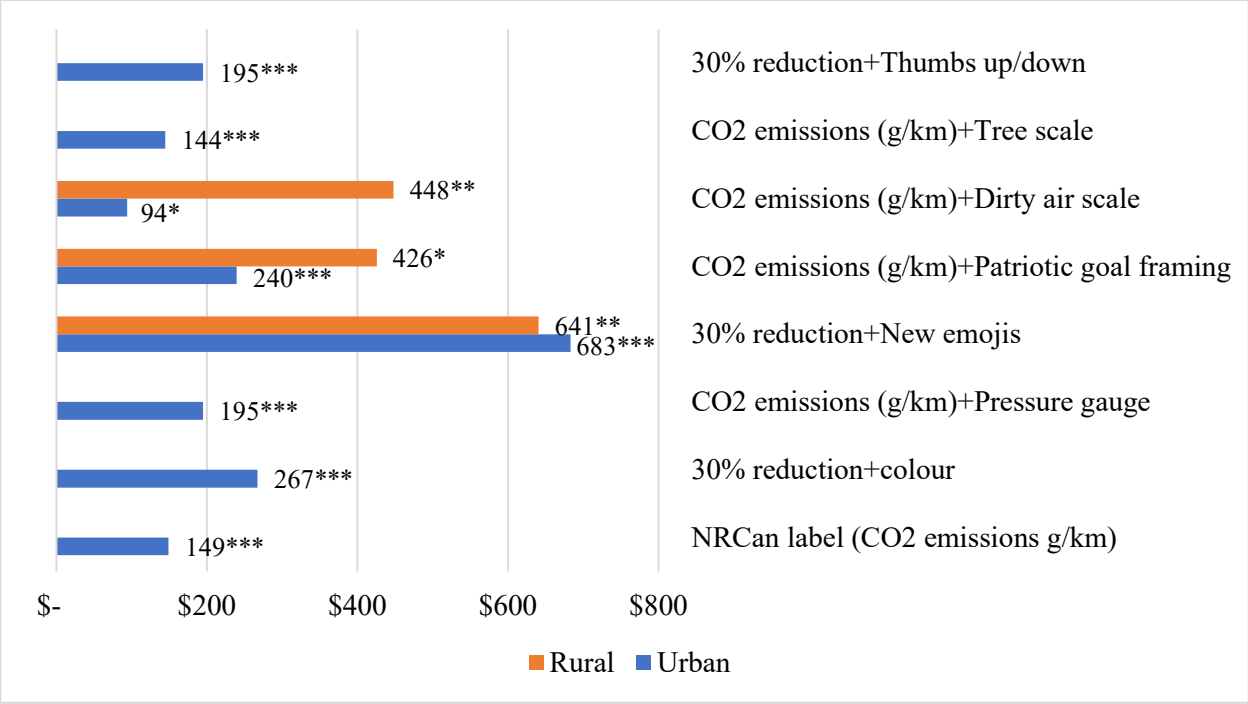
4.3 Urban-Rural Residence

Considering the marginal WTP for CO_2 emissions reduction due to treatment effects, in this segmentation (see **TABLE 8**), the influence of the emoticon was strongest again, with the basic reference WTP by urban residents higher than for rural. This follows the findings presented in the background where urban residents were more concerned about climate change and were more supportive of carbon taxes. However, this could also be due to the higher income levels in urban areas in Canada (Fong, 2017). The total WTP under different framings for urban-rural residences can be seen in **Figure 4**. In contrast to the previous segmentations, for rural residents, the Dirty air scale and the Patriotic scales were the next best with all of the other framings not significant. For the urban population, the use of color to highlight being high (red) or low (blue) and the Patriotic scale were the next best, with all other framings found to be statistically different from 0 (unlike for the rural respondents).

TABLE 8 Segmentation Analysis with Urban and Rural Residence

	Urban		Rural	
Name	Estimate		Estimate	
ASC-BEV (ref.)	0		0	
ASC-GAS	-0.0322		0.18	
ASC-PHEV	0.33	***	0.366	**
Price (10,000 C$)	-0.688	***	-0.678	***
Discount rate (r) (monthly)	0.0167	***	0.0208	***
Range (km)	8.22	***	10.6	
Reference WTP for CO_2 (kg per month)	0.149	***	0.0827	
NRCan label (ref.)	0		0	
30% reduction + Color	0.118	**	0.182	
CO_2 emissions (g/km) + Pressure gauge	0.0456		-0.00386	
30% reduction + New emoticons	0.534	***	0.558	**
CO_2 emissions (g/km) + Patriotic goal framing	0.0905	*	0.343	*
CO_2 emissions (g/km) + Dirty air scale	-0.0549		0.365	*
CO_2 emissions (g/km) + Tree scale	-0.00453		0.189	
30% objective + carbon tax + Thumbs up/down	0.0459		-0.302	
Estimation report				

Number of estimated parameters	13	13
Sample size	21468	2712
Init log likelihood	-14880.48	-1879.815
Final log likelihood	-13976.74	-1700.096
LR-Test (full model)	1807.496	359.4387
Rho-square for the init. model	0.0607	0.0956
Rho-square-bar for the init. model	0.0599	0.0887
Akaike Information Criterion	27979.47	3426.192
Bayesian Information Criterion	28083.14	3502.962
Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.		



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 4 Willingness to pay for tonnes of CO_2 under different framings for urban-rural residence (only significant findings are displayed)

4.4 Politics

The political scale was divided into five groups: Extreme Left, Left, Neutral, Right, and Extreme Right. Individuals who responded that they preferred not to answer were excluded. As seen in **TABLE 9**, for this segmentation, differences in vehicle type preferences were found. For the Extreme Left group, a statistical

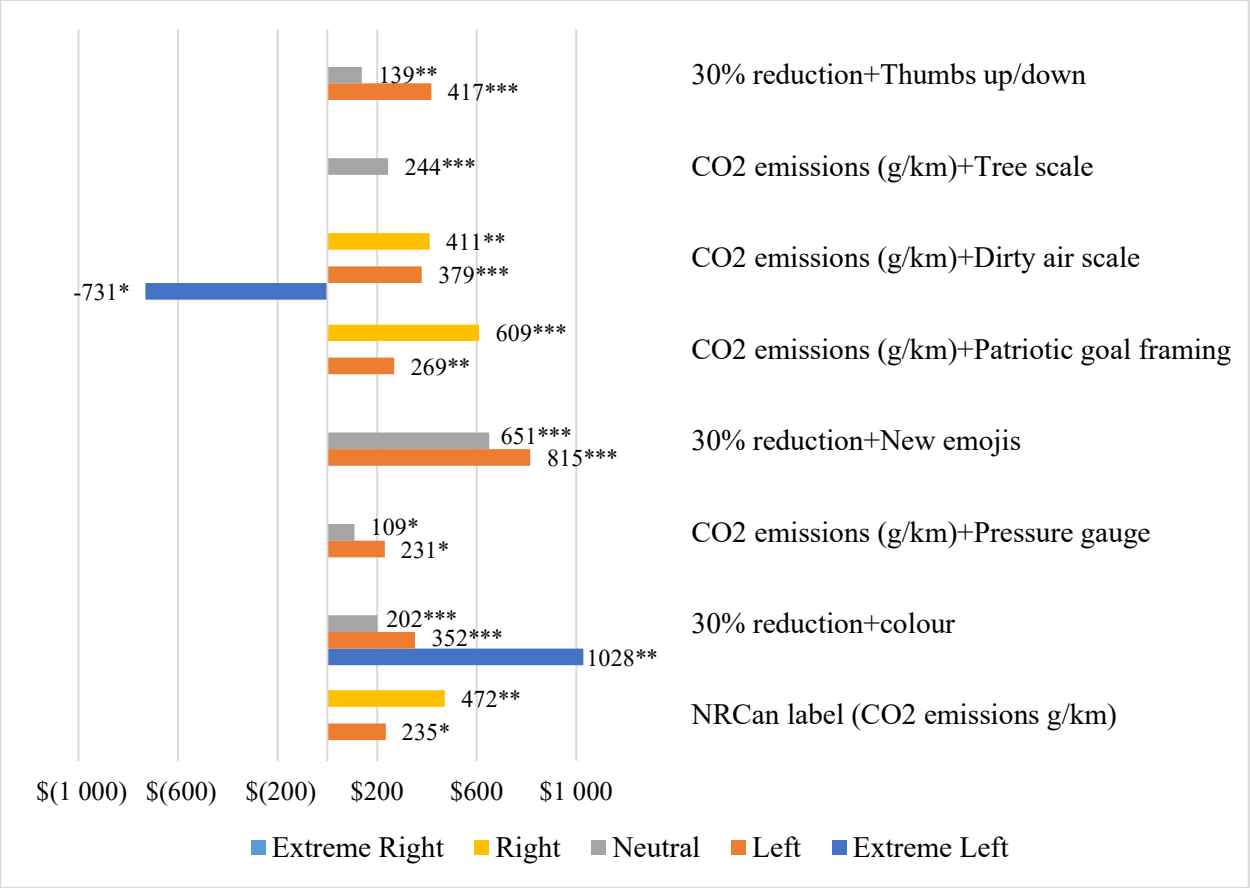
difference can be seen between the electric and gasoline vehicles, and gasoline vehicles are the least preferred. Also noteworthy is that those on the Extreme Right showed no preference for vehicle types.

The total WTP under different framings for different political spectrums can be seen in **Figure 5**. For the Extreme Left, the Color framing was the most effective with the highest WTP, and the Dirty air scale was the weakest framing which produced a negative WTP. For the Left, the new emoticon was the strongest, only with the Tree scale having a negative effect. For Neutrals (the largest group), the new emoticon followed by the Tree scale was the strongest, while the NRCan label, Patriotic framing and Dirty air scale were not significant. For those classified as Right, the Patriotic framing was the strongest influencer, and the Pressure gauge was the least influential (with a negative WTP). For those on the Extreme Right, no framing was found to be significant. Overall, those classified as being Left were the most WTP, though the Extreme left saw next to no influence. Boulianne et al. (Boulianne et al., 2021) stated that individuals on the left side spectrum are more concerned about climate change than those on the right, but here we see that the influence of climate emissions on vehicle choice is not necessarily linear.

TABLE 9 Segmentation Analysis with Politics

	Extreme Left		Left		Neutral		Right		Extreme Right	
Name	Estimate		Estimate		Estimate		Estimate		Estimate	
ASC-BEV (ref.)	0		0		0		0		0	
ASC-GAS	-0.652	*	-0.319		0.106		-0.165		0.257	
ASC-PHEV	0.345		0.353	***	0.425	***	0.289	**	-0.347	
Price (10,000 C$)	-0.674	***	-0.690	***	-0.790	***	-0.756	***	-0.459	***
Discount rate (r) (monthly)	0.0218	**	0.0165	***	0.016	***	0.0242	***	0.0149	*
Range (km)	11.6		3.77		12.5	***	0.977		-7.87	
Reference WTP for CO_2 (kg per month)	0.379		0.235	*	0.0137		0.472	**	0.679	
NRCan label (ref.)	0		0		0		0		0	
30% reduction + Color	0.649		0.117		0.188	***	-0.199		-1.38	
CO_2 emissions (g/km) + Pressure gauge	-0.0902		-0.00371		0.0953		-0.53	**	-0.62	

30% reduction + New emoticons	0.169		0.58	***	0.637	***	-0.398	**	-0.155	
CO_2 emissions (g/km) + Patriotic goal framing	0.0266		0.0337		0.0722		0.137		-0.951	
CO_2 emissions (g/km) + Dirty air scale	-1.11	**	0.144		0.0897		-0.0607		-0.632	
CO_2 emissions (g/km) + Tree scale	-0.373		-0.347	***	0.23	***	-0.323	*	-1.77	
30% objective + carbon tax + Thumbs up/down	-0.261		0.182		0.125	*	-0.343	*	-0.613	
Estimation report										
Number of estimated parameters	13		13		13		13		13	
Sample size	1248		4224		9984		3348		792	
Init log likelihood	-865.0477		-2927.854		-6920.381		-2320.657		-548.9726	
Final log likelihood	-800.4917		-2746.362		-6326.544		-2087.001		-448.3658	
LR-Test (full model)	129.112		362.9842		1187.675		467.3121		201.2135	
Rho-square for the init. model	0.0746		0.062		0.0858		0.101		0.183	
Rho-square-bar for the init. model	0.0596		0.0575		0.0839		0.0951		0.16	
Akaike Information Criterion	1626.983		5518.723		12679.09		4200.001		922.7317	
Bayesian Information Criterion	1693.664		5601.254		12772.8		4279.511		983.501	
Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.										



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 5 Willingness to pay for tonnes of CO_2 under different framings for different political spectrum (only significant findings are displayed)

4.5 Climate change stage of change

As shown in **TABLE 10**, for those not concerned about climate change, the Tree scale followed by the Pressure gauge and the Dirty air scale were all very effective. However, in contrast to most other groups, this group was strongly negatively influenced by the emoticons. For those who say they are concerned, but have no intention of reducing their emissions, they are influenced by CO_2 emissions information, but there is no statistical difference between the framings. For individuals who said they were concerned but were not sure how to lower emissions, the framing using color was the most effective, whereas Tree Scale, Thumbs up/down, and Pressure gauge were the least effective. Individuals who plan to reduce their emissions (the largest group) were most influenced by the emoticons, while the Dirty air and Tree scales (overall negative WTP) were the least effective. Those results contrast strongly with those not concerned.

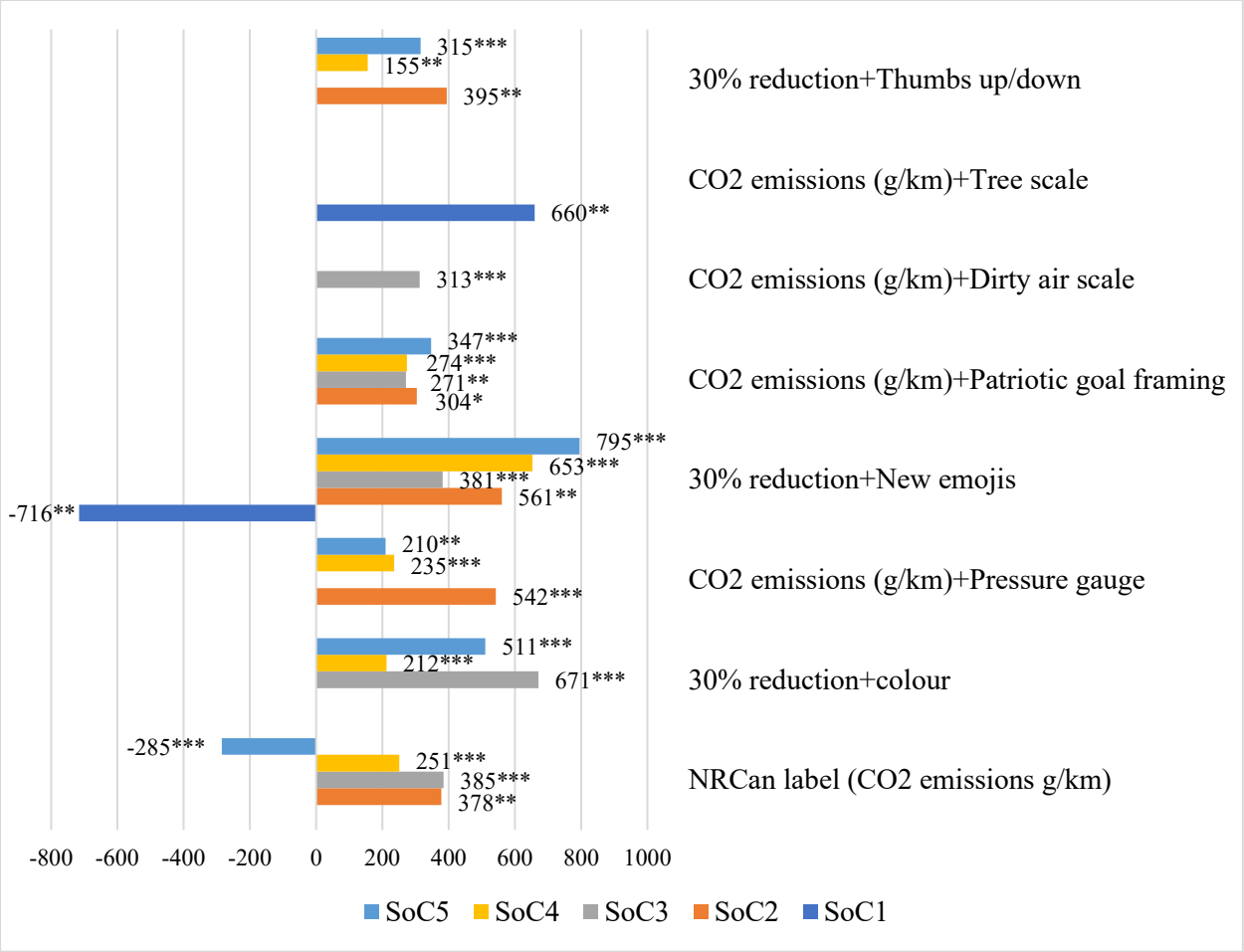
Finally, individuals who say that they have already reduced their emissions were most influenced by the emoticon and then color framing. They were least influenced by the NRCan label.

A difference in vehicle preference is also found here. Similar to those on the Extreme Right, no preference is found for those not concerned about climate change. Those not intending to reduce their emissions are the only group found to favor gasoline-powered vehicles. The majority of the population (stages 3 through 5) prefer plug-in hybrids. The largest group, those planning to make reductions, preferred battery-electric vehicles to gasoline ones. These results are in line with the outcomes of previous studies (Bas et al., 2021; Kim et al., 2018), in which environmental concerns were shown to increase intention for EV adoption. The total WTP under different framings for different CC-SoC stages can be seen in **Figure 6**.

TABLE 10 Segmentation Analysis with CC-SoC

	Not concerned	Concerned, but don't intend to lower emissions	Concerned, not sure how to lower emissions	Concerned, will lower emissions	Concerned, have lowered emissions
Name	Estimate	Estimate	Estimate	Estimate	Estimate
ASC-BEV (ref.)	0	0	0	0	0
ASC-GAS	0.351	0.737 ***	0.0146	-0.41 ***	0.0498
ASC-PHEV	0.0482	0.198	0.286 ***	0.448 ***	0.526 ***
Price (10,000 C$)	-0.692 ***	-0.817 ***	-0.764 ***	-0.769 ***	-0.619 ***
Discount rate (r) (monthly)	0.0213 ***	0.0194 ***	0.0175 ***	0.0176 ***	0.0134 ***
Range (km)	2.93	-0.0216	5.8	12.1 ***	15.1 ***
Reference WTP for CO_2 (kg per month)	-0.141	0.378 **	0.385 ***	0.251 ***	-0.285 ***
NRCan label (ref.)	0	0	0	0	0
30% reduction + Color	-0.291	-0.165	0.286 ***	-0.0388	0.796 ***
CO_2 emissions (g/km) + Pressure gauge	0.513 **	0.164	-0.358 ***	-0.0158	0.495 ***
30% reduction + New emoticons	-0.575 *	0.183	-0.00377	0.402 ***	1.08 ***

CO_2 emissions (g/km) + Patriotic goal framing	0.094		-0.0738		-0.114		0.0231		0.632	***
CO_2 emissions (g/km) + Dirty air scale	0.422	*	-0.139		-0.0723		-0.181	**	0.21	**
CO_2 emissions (g/km) + Tree scale	0.801	**	-0.114		-0.452	***	-0.158	**	0.416	***
30% objective + carbon tax + Thumbs up/down	0.0931		0.0166		-0.368	***	-0.0957		0.6	***
Estimation report										
Number of estimated parameters	13		13		13		13		13	
Sample size	2664		3108		4644		8736		5028	
Init log likelihood	-1846.544		-2154.301		-3218.976		-6055.334		-3485.144	
Final log likelihood	-1416.559		-1577.63		-2933.85		-5652.668		-3242.613	
LR-Test (full model)	859.9695		1153.343		570.25		805.3316		485.0621	
Rho-square for the init. model	0.233		0.268		0.0886		0.0665		0.0696	
Rho-square-bar for the init. model	0.226		0.262		0.0845		0.0644		0.0659	
Akaike Information Criterion	2859.119		3181.26		5893.701		11331.34		6511.226	
Bayesian Information Criterion	2935.657		3259.803		5977.464		11423.31		6596.022	
Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.										



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 6 Willingness to pay for tonnes of CO_2 under different framings for different CC-SoC stages (only significant findings are displayed)

4.6 Income

As shown in **TABLE 11**, higher incomes were not linearly linked with a greater WTP for emissions. For the highest income group and the two lowest, the new emojis resulted in the highest WTP. The lowest-income group responded negatively to the thumbs up/down framing while the wealthiest group responded negatively to the dirty-air framing. In contrast, the dirty-air framing was the strongest for the middle-income group (C$50-74.9k), while patriotic was the strongest for the second-highest income group.

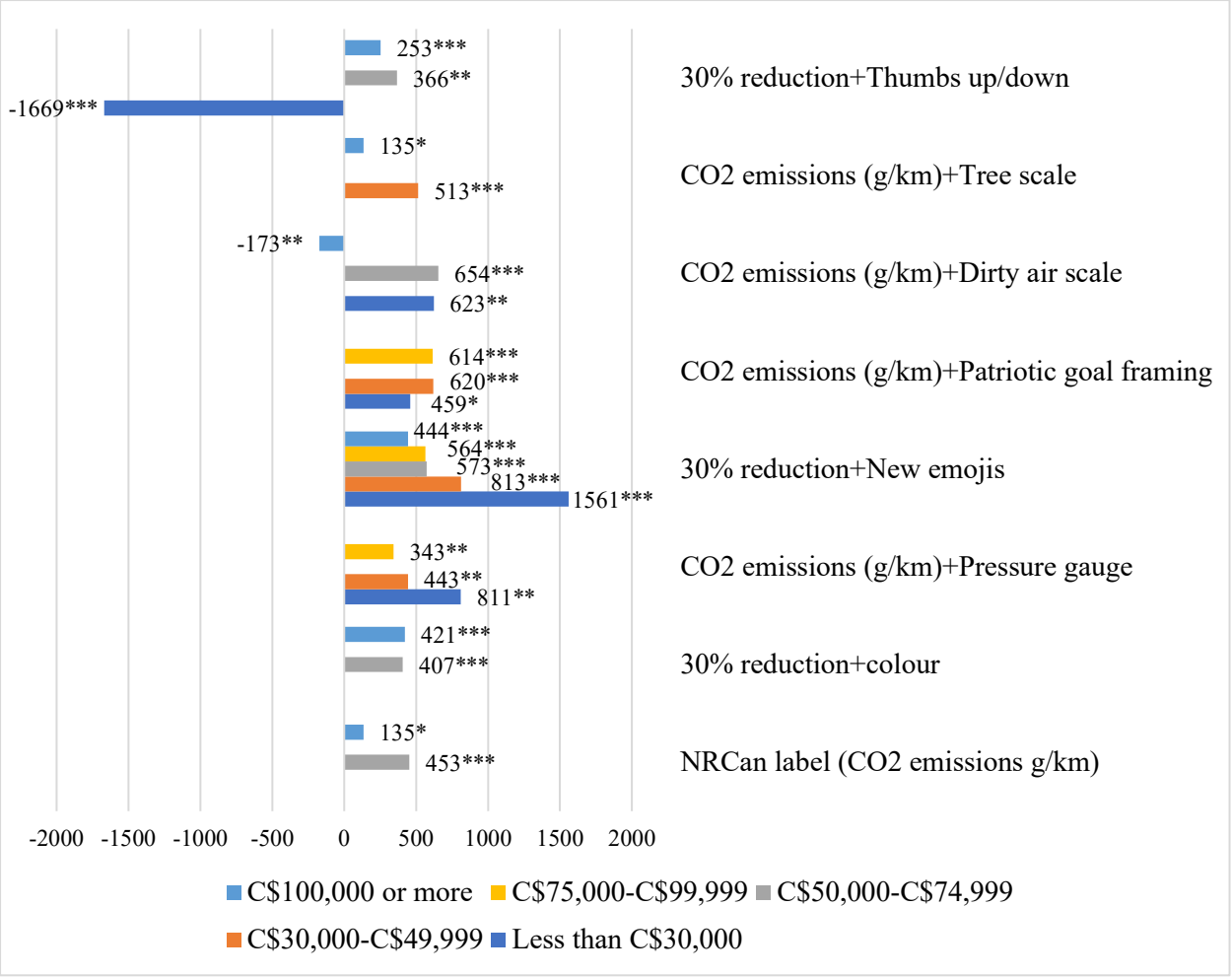
The lowest income group did not show a preference for a certain type of vehicle. All of the rest showed a preference for plug-in hybrid vehicles. The range of the vehicles seems to only have been a concern for the higher income groups.

In all cases, it is not clear from this analysis why one income group might prefer a different framing as they were not based on theories related to income. The total WTP under different framings for different household incomes can be seen in **Figure 6**.

TABLE 11 Segmentation Analysis with Household Income

	Less than C$30,000		C$30,000-C$49,999		C$50,000-C$74,999		C$75,000-C$99,999		C$100,000 or more	
Name	Estimate		Estimate		Estimate		Estimate		Estimate	
ASC-BEV (ref.)	0		0		0		0		0	
ASC-GAS	-0.269		0.164		0.0389		-0.0129		-0.198	
ASC-PHEV	0.0571		0.382	***	0.311	***	0.399	***	0.38	***
Price (10,000 C$)	-0.677	***	-0.691	***	-0.693	***	-0.681	***	-0.769	***
Discount rate (r) (monthly)	0.0238	***	0.0183	***	0.0197	***	0.0186	***	0.0153	***
Range (km)	3.32		3.26		1.72		11.5	*	11.5	***
Reference WTP for CO_2 (kg per month)	0.000803		-0.0827		0.453	***	0.118		0.135	***
NRCan label (ref.)	0		0		0		0		0	
30% reduction + Color	-0.149		0.21		-0.0463		-0.323	**	0.286	***
CO_2 emissions (g/km) + Pressure gauge	0.81	**	0.526	***	-0.323	**	0.225		-0.0914	***
30% reduction + New emoticons	1.56	***	0.896	***	0.12		0.446	***	0.309	***
CO_2 emissions (g/km) + Patriotic goal framing	0.458	*	0.703	***	-0.399	**	0.496	***	-0.0273	***
CO_2 emissions (g/km) + Dirty air scale	0.622	**	0.293	*	0.201		-0.114		-0.308	**
CO_2 emissions (g/km) + Tree scale	0.127		0.596	***	-0.258	*	-0.286	**	-0.000204	***

30% objective + carbon tax + Thumbs up/down	-1.67 ***	0.283 *	-0.087	0.096	0.118 ***
Estimation report					
Number of estimated parameters	13	13	13	13	13
Sample size	2556	3228	4476	3984	7320
Init log likelihood	-1771.684	-2237.479	-3102.527	-2761.498	-5073.837
Final log likelihood	-1573.895	-2030.503	-2841.765	-2554.546	-4742.051
LR-Test (full model)	395.5779	413.9515	521.5228	413.9051	663.5724
Rho-square for the init. model	0.112	0.0925	0.084	0.0749	0.0654
Rho-square-bar for the init. model	0.104	0.0867	0.0799	0.0702	0.0628
Akaike Information Criterion	3173.79	4087.007	5709.531	5135.092	9510.102
Bayesian Information Criterion	3249.791	4166.042	5792.815	5216.862	9599.781
Note: *, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.					



*, **, and *** represent the significance difference at the levels of 0.1, 0.05, and 0.01, respectively.

Figure 7 Willingness to pay for tonnes of CO_2 under different framings for different household incomes (only significant findings are displayed)

4.7 Limitations

The results are not representative of the entire Canadian population as the experiment did not gather responses from the entire country and it excluded people who do not have a driver's license as it was deemed necessary in order for the experiment on vehicle choice to be a realistic choice for them. The framings tested are not the only possible framings that could exist and further framings should be tested to improve on the current results. As well, the emissions information here only refers to tailpipe emissions and does not consider the entire life-cycle emissions. Finally, these results are stated preferences as opposed to

revealed preferences. Future experiments where individuals make real-life choices with different emissions framings would be a considerable contribution.

5. GENERAL DISCUSSION

The results above demonstrate that depending on the context, different approaches to presenting climate change emissions will likely result in different outcomes. Overall, the framing that applied the new emoticons was the most effective. This framing started by contextualizing the CO_2 emissions information (given in grams/km) with respect to the Canadian government's (2021) reduction target (following results from Daziano et al., 2017). Previous results on using emoticons were not as strong (Wang et al., 2021). However, building on results related to color (Wang et al., 2021) and from Feinberg and Willer (2013) on highlighting the "dirty air" aspect of emissions, a considerably larger influence could be found as compared to the previous best "hedonic" (Wang et al., 2021). Emoticons have been proposed as a means to convey an injunctive norm (i.e., what society believes is the "correct" behavior; Schultz et al, 2007; Gaker and Walker, 2013). This relates to the "social norms" influence that is proposed as a tool to help with climate change mitigation (Creutzig et al., 2022).

A number of hypotheses were presented in the literature review with respect to the different approaches to segmentation. For culture, it was anticipated that the French-Canadian population would have a higher WTP as they score higher on Harmony (living in harmony with nature) as opposed to English-Canadians who score higher on Mastery (using the environment for society's goals). However, this is not apparent in the results. The English respondents had the highest WTP, C$733/tonne, though the French-speaking respondents were not far behind at C$612/tonne. One notable difference is the patriotic goal framing where the English respondents were over 3 times more influenced. This may relate to Quebec being recognized as a Nation within the country of Canada.

For rural and urban respondents, some research suggested that urban dwellers are more concerned about the environment, though those in the rural areas were expected to respond stronger to an environmental stewardship framing. As with the other segments, the emoticons were the strongest

(C$683/tonne for urban, C$641/tonne for rural). The rural area did respond stronger to the dirty air framing, but also the Patriotic goal framing. The dirty air framing is perhaps the inverse of expectations as urban dwellers are considered to be more exposed to that type of problem.

For the political spectrum, previous research has generally found that people on the left are more concerned about the environment. The highest WTP was found with the extreme left (C$1028/tonne with the hedonic color framing), and the second highest WTP was found with the left (C$815/tonne with the emoticon framing). However, at the same time, the lowest WTP was found for the extreme left (C$731/tonne) with the Dirty air framing. It is not clear why this might be. None of the framings had a measurable effect on the extreme right, while the Patriotic goal framing was the strongest for the right at C$609/tonne which is still considerable. The Dirty air framing was also effective with those who identify as being on the right (but not extreme right). As such, these two results do support the proposition that framing that applies the binding foundations are likely more effective for those on the right. The other consistent finding might be that those in the Left category responded positively to the two injunctive norm framings (emoticon and thumb framings).

For the Climate Change Stage of Change measure, the expectation was that as the level goes higher, people would be more motivated by the climate change emissions. To some extent, this is supported as those who identify as being on the highest level (having already made changes to reduce their emissions) had the highest WTP at C$795/tonne (emoticon framing). However, the next highest was with those who are not concerned about climate change. Those individuals had a WTP of C$660/tonne when the tree emoticon was used. Why this might be is not clear, though one hypothesis might be that they interpreted it in the opposite way: that as plants absorb CO_2, a lusher plant would imply more emissions. This might be the case as the only other format to have a measurable influence on this group was the emoticon, though it resulted in a negative WTP of C$716/tonne, implying that this group is willing to pay to increase their emissions. Fortunately, the emoticon framing had a significant positive influence on the vast majority of the respondents.

Finally, income was not expected to have an influence. However, the findings for the emoticon suggest an inverse relationship as those who had lower household incomes had a higher WTP. Here, we see an odd result where the lowest income group had the strongest negative WTP recorded (C$1669/tonne with the Thumb framing) and the highest WTP recorded (C$1561/tonne with the Emoticon framing).

The most effective framing approach used here considers both the efficiency of the motor (emissions per output) and its general use. This could be applied to other appliances by considering their use. For example, a large washing machine might have lower emissions per clothing item if used when full. However, if the practice is to run the washing machine every week regardless of how full it is, this would result in larger emissions based on use. As the IPCC reports (Creutzig et al., 2022), both energy-efficient technological advances and behavioral change are needed. Behavioral change is likely to require useful information with respect to consumer goods so that individuals can understand how their (mobility) choices relate to overall societal goals such as the climate crisis.

6. CONCLUSIONS

Segmentation of a Canada-wide survey was conducted to examine how different groups respond to different framings of GHG emissions information. The results demonstrate that for nearly all groups, the addition of the new emoticons developed here and the following theories on color, injunctive norms, and moral foundations were by far the most effective. However, exceptions were found when the sample was segmented by climate change stage of change and politics. For politics, those on both extremes were not influenced, though a Dirty Air scale actually produced a negative WTP for those on the extreme left. Perhaps surprisingly, those who say they are not concerned about climate change were most influenced by a Tree scale.

These results will help various agencies better communicate CO_2 emissions with different groups of the population. This knowledge is not limited to transport but could be applied to other major decisions (homes, flights, appliances, etc.). Future studies should look to examine how choices might be influenced if the full life-cycle emissions were used rather than simply the tailpipe emissions.

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: **Study conception and design:** E.O.D. Waygood, B. Wang, A. Loiselle, M. Feinberg, Ricardo A. Daziano; **Data collection:** E.O.D. Waygood, B. Wang, X. Ji, H. Naseri; **Analysis and interpretation of results:** E.O.D. Waygood, B. Wang, X. Ji, H. Naseri, Ricardo A. Daziano, Z. Patterson; **Draft manuscript preparation:** B. Wang, E.O.D. Waygood, X. Ji, H. Naseri, A. Loiselle. All authors reviewed the results and approved the final version of the manuscript.

REFERENCES

Agency, U.S.E.P., 2018. Fuel Economy.

Allcott, H., Wozny, N., 2014. Gasoline Prices, Fuel Economy, and the Energy Paradox. *Rev Econ Stat* 96(5), 779-795.

Bas, J., Zou, Z., Cirillo, C., 2021. An interpretable machine learning approach to understanding the impacts of attitudinal and ridesourcing factors on electric vehicle adoption. *Transportation Letters*, 1-12.

Boulianne, S., Belland, S., Sleptcov, N., Larsson, A.O., 2021. Climate Change in the 2019 Canadian Federal Election. *Climate* 9(5), 70.

Boykoff, M.T., 2009. We speak for the trees: Media reporting on the environment. *Annual review of Environment and Resources*, *34*, pp.431-457.

Canada, E.a.C.C., 2016. *Canada's mid-century long-term low greenhouse gas emission development strategy*, Gatineau, Québec.

ChoiceMetrics, 2018. *Ngene 1.2 user manual & reference guide*. Choice Metrics, Sydney.

Creutzig, F., Roy, J., Devine-Wright, P., Díaz-José, J., Geels, F., Grubler, A., Maïzi, N., Masanet, E., Mulugetta, Y., Onyige-Ebeniro, C., 2022. Demand, services and social aspects of mitigation, *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 752-943.

Daziano, R.A., Waygood, E.O.D., Patterson, Z., Feinberg, M., Wang, B., 2021. Reframing greenhouse gas emissions information presentation on the Environmental Protection Agency's new-vehicle labels to increase willingness to pay. *Journal of Cleaner Production* 279.

Daziano, R.A., Waygood, E.O.D., Patterson, Z., Kohlova, M.B., 2017. Increasing the influence of CO2 emissions information on car purchase. *Journal of Cleaner Production* 164, 861-871.

Feinberg, M., Willer, R., 2013. The Moral Roots of Environmental Attitudes. *Psychological Science* 24(1), 56-62.

Fong, F., 2017. Income Inequality in Canada: The Urban Gap. *Chartered Professional Accountant Canadia*, 1-20.

Gaker, D., Walker, J.L., 2013. Revealing the Value of "Green" and the Small Group with a Big Heart in Transportation Mode Choice. *Sustainability* 5(7), 2913-2927.

Graham, J., Haidt, J., Nosek, B.A., 2009. Liberals and Conservatives Rely on Different Sets of Moral Foundations. *J Pers Soc Psychol* 96(5), 1029-1046.

Grubb, M., Okereke, C., Arima, J., Bosetti, V., Chen, Y., Edmonds, J., Gupta, S., Köberle, A., Kverndokk, S., Malik, A., 2022. *Introduction and framing, IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 150-213.

Haidt, J., Joseph, C., 2007. The moral mind: How five sets of innate intuitions guide the development of many culture-specific virtues, and perhaps even modules. *The innate mind* 3, 367-391.

Hensher, D.A., Greene, W.H., 2011. Valuation of Travel Time Savings in WTP and Preference Space in the Presence of Taste and Scale Heterogeneity. *Journal of Transport Economics and Policy* 45, 505-525.

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. *Applied choice analysis, 2 ed*. Cambridge University Press, Cambridge.

Jones, R.E., Dunlap, R.E., 1992. The Social Bases of Environmental Concern - Have They Changed over Time. *Rural Sociol* 57(1), 28-47.

Kennedy, E.H., Beckley, T.M., McFarlane, B.L., Nadeau, S., 2009. Rural-Urban Differences in Environmental Concern in Canada. *Rural Sociol* 74(3), 309-329.

Kim, M.K., Oh, J., Park, J.H., Joo, C., 2018. Perceived value and adoption intention for electric vehicles in Korea: Moderating effects of environmental traits and government supports. *Energy* 159, 799-809.

Lowe, G.D., Pinhey, T.K., 1982. Rural-Urban Differences in Support for Environmental-Protection. *Rural Sociol* 47(1), 114-128.

McCright, A.M., Dunlap, R.E., Marquart-Pyatt, S.T., 2016a. Political ideology and views about climate change in the European Union. *Environmental Politics* 25(2), 338-358.

McCright, A.M., Marquart-Pyatt, S.T., Shwom, R.L., Brechin, S.R., Allen, S., 2016b. Ideology, capitalism, and climate: Explaining public views about climate change in the United States. *Energy Research & Social Science* 21, 180-189.

Mildenberger, M., Howe, P., Lachapelle, E., Stokes, L., Marlon, J., Gravelle, T., 2016. The Distribution of Climate Change Public Opinion in Canada. *Plos One* 11(8), e0159774.

NRCan, 2019. *Oil Supply and Demand*. Nat. Resour, Canada.

Prochaska, J.O., Redding, C.A., Evers, K.E., 2015. The transtheoretical model and stages of change. *Health behavior: Theory, research, and practice* 97.

Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldstein, N.J. and Griskevicius, V., 2007. The constructive, destructive, and reconstructive power of social norms. Psychological science, 18(5), pp.429-434.

Schwartz, S.H., 2004. Mapping and interpreting cultural differences around the world. *International studies in sociology and social anthropology*, 43-73.

Schwartz, S.H., 2008. The 7 Schwartz cultural value orientation scores for 80 countries. *ResearchGate [Internet]*.

Vanliere, K.D., Dunlap, R.E., 1980. The Social Bases of Environmental Concern - a Review of Hypotheses, Explanations and Empirical-Evidence. *Public Opin Quart* 44(2), 181-197.

Wang, B., Waygood, E.O.D., Daziano, R.A., Patterson, Z., Feinberg, M., 2021. Does hedonic framing improve people's willingness-to-pay for vehicle greenhouse gas emissions? *Transportation Research Part D: Transport and Environment* 98, 102973.

Waygood, E.O.D., Avineri, E., 2011. Does" 500g of CO2 for a five mile trip" mean anything? Towards more effective presentation of CO2 information, Washington, D.C.

Waygood, E.O.D., B., W., A., D.R., Z., P., M.(ND), B.K., 2021a. The Climate Change Stage of Change Measure: Vehicle Choice Experiment. *Journal of Environmental Planning and Management*.

Waygood, E.O.D., Wang, B., Daziano, R.A., Patterson, Z., Braun-Kohlová, M., 2021b. The Climate Change Stage of Change Measure: Vehicle Choice Experiment. *Journal of Environmental Planning and Management*.

Young, N., Dugas, E., 2012. Comparing Climate Change Coverage in Canadian English- and French-Language Print Media: Environmental Values, Media Cultures, and the Narration of Global Warming. *Can J Sociol* 37(1), 25-54.