IMPROVING HOW CO2 EMISSIONS INFORMATION IS PRESENTED: VEHICLE CHOICE EXPERIMENTS

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In the fight against Climate Change, improving the strength of people's response to emissions is an important consideration, especially for consumer items that will have a large impact like personal vehicles. In Canada, motor vehicles are requested to have a vehicle label which displays information such as liters of fuel per 100 km, the estimated cost of energy, and then environmental information on carbon dioxide (CO2) emissions and smog impacts. The CO2 emissions information is a scale from 1 to 10 with ten being the best. However, this information is scaled with comparison to other similar vehicles. The problem with this is that it does not relate that information to the goal: reducing emissions. Further, as is evident from watching commercials, people are influenced not only by rational information, but also emotional and social norm information. This short article summarizes research from experiments carried out over the past few years on this topic by the research team.

Key Words : *climate change; communication; vehicle purchase; vehicle choice; information framing*

1. INTRODUCTION

The climate crisis is likely the greatest threat facing humans. One major contributing factor to greenhouse gas (GHG) emissions is from the transport sector (*1*). As an individual behavior, apart from not having children, how one chooses to get around is one of the most important choices in terms of climate change impact (*2*). Previous research has demonstrated that people do not really understand GHG emissions information (*3*), which means that its impact on their choices is likely to be limited or non-existant. As such, it is imperative to improve how such information is presented so that it can influence people to make more climate-friendly choices.

(1) Previous research

Examining a number of different formats to present GHG emissions, in particular carbon dioxide (CO2) emissions, previous research using qualitative

and quantitative methods found that people have a limited ability to interpret CO2 emissions, thus making it hard to apply to choices (*4; 5*). Individuals who are already concerned about climate change responded to essentially all GHG framings (*5*), but those who are not environmentally motivated have little to no reaction when the information is not framed well (*6; 7*).

The general approach to framing emissions is to give context to that information to help people understand. This can be done in a number of ways such as comparing to similar products, using financial levers such as a carbon tax, or with respect to a societal target.

The current approach by Natural Resources Canada (NRCan) is to frame the emissions on a scale from 1 to 10 (with 10 being the best) based on similar vehicle types. The problem with this is that it does not relate that information to the goal: reducing emissions. With such an approach to framing, individuals considering a Sport Utility Vehicle (SUV) might believe that they are purchasing an environmentally friendly vehicle because the category is high, yet in the context of reducing emissions, that choice would greatly exceed the needed reductions.

Another approach is to give meaning to those emissions through a financial disincentive such as a carbon tax. With such a framing, an individual would consider whether the additional cost of the emissions is within their budget. However, a few problems exist with this approach. One is an equity concerns where the wealthy can pay to pollute more, with many impacts of those emissions (including health) impacting less wealth people or countries. One is that the relative impact of that cost might seem minimal in comparison to the context of purchasing the vehicle (10s of thousands of dollars to purchase vs a few hundred dollars a year in taxes). Another is the problem where people may feel that they have paid to pollute and it is thus not a problem to produce more emissions.

Rather than a financial approach, emissions could be framed with respect to a reduction target. With such an approach, the use of the vehicle and its related emissions would be contextualized with respect to a country's reduction target. This framing approach relates to being a "good citizen".

In our previous research, the societal framing was found to be the most influential in the USA (*8*) and in Canada (*9*) over the current labels (US-EPA and Natural Resouces Canada) and a carbon tax equivalent to $C 50/tonne (all dollar values in this study are given in Canadian dollars; $C 1 ≈ 100 yen). In the Canadian study, results also suggested that integrating colour and emojis to present social norms showed further promise.

(2) New research

Building on our previous findings, new techniques for framing will be tested here. Previous research has primarily focused on what are termed "gain" and "norm" framings from a goal-framing perspective. Gain framing (*10*) relates to protecting one's own resources such as money. Norm framing relates to societal norms such as reduction targets. Another framing based on this theory would be hedonic framing which relates to emotions.

Emojis can act to convey a social norm called "injunctive norms". These norms are those that relate to what society approves of. Previous research in household energy use found that it could be effective communication tools (*11*). Our previous work found that emojis might be effective, but that small modifications might be required (*9*).

2. METHODS

Discrete choice experiments were carried out online using visual mock-ups of the current NRCan new-vehicle labels. For the DCE design, the experiment attributes with different levels under choice scenarios include real-world prices, fuel costs, emissions and electric vehicle range (where relevant). Annual emissions are determined using the tailpipe CO2 emissions in grams of CO2 per kilometer and an annual distance driven of 20,000 km following the NRCan distance applied to calculate annual fuel costs. Each participant completed 12 choice scenarios for one of the framings (see below). They were randomly assigned to one of the framings.

Along with various socio-demographic questions, the participants were also asked about their Climate Change Stage-of-Change (CC-SoC; see REF). This measure developed based on the Transtheoretical Model (*12*) and identifies five groups based on their concern over climate change and their stage of change towards reducing emissions. The five levels of CC-SoC are defined as follows:

CC-SoC1: Not concerned;
CC-SoC2: Concerned, but won't reduce emissions;
CC-SoC3: Concerned, don't know what to do;
CC-SoC4: Concerned, will reduce emissions;
CC-SoC5: Concerned, have reduced emissions.

(1) Sample

2700 repondents in the six most populace provinces of Canada (there are 10 provinces in total) participated. Six provinces, including British Columbia, Quebec, Ontario, Alberta, Saskatchewan, and Manitoba, contribute to over 94% of total GHG emissions in Canada (*13*). All respondents were adults with a driver's licence so that the choice was a

relevant one. After data cleaning that includes removing respondents who failed at a few "trap questions" that test whether the respondent is paying attention, there were 2012 valid participants.

Table 1 Select characteristics of participants.

Characteristics	Freq.
Gender	
Male	970
Female	1042
Age	
19-29	309
30-39	344
40-49	421
50-59	469
60+	469
Climate change stage of change	
CC-SoC1	222
CC-SoC2	259
CC-SoC3	387
CC-SoC4	726
CC-SoC5	418
Currently own a vehicle	
Yes	1818
No	194

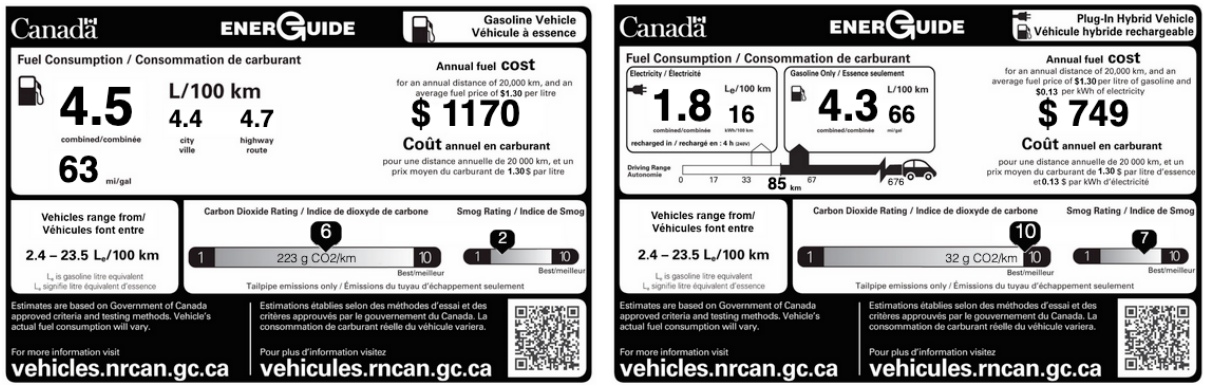
(2) Framings

Eight framings were tested. They are listed in Table 2 along with the reason for testing.

Table 2 Framings tested.

Framing	Functional name	Reason for testing
1	NRCan label	The current label used by Natural Resource Canada; acting as a reference.
2	Hedonic framing	Previously found to be the most influential (*9*); color is used to link with emotions: blue for calm, red for angry.
3	Pressure gauge	This is a graphic representation as focus groups and general feedback suggested that the wording used in (#2) could be confusing.
4	New emojis	This combined hedonic information (color), injunctive norms (emojis), and air quality (coughing; (*14*)).
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. (*14*)
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) (*14*)
7	Trees	This framing is related to environmental stewardship and the link between trees and the environment. (*15*)
8	Injunctive norm	The thumbs up/thumbs down are used to project a "societal approval"

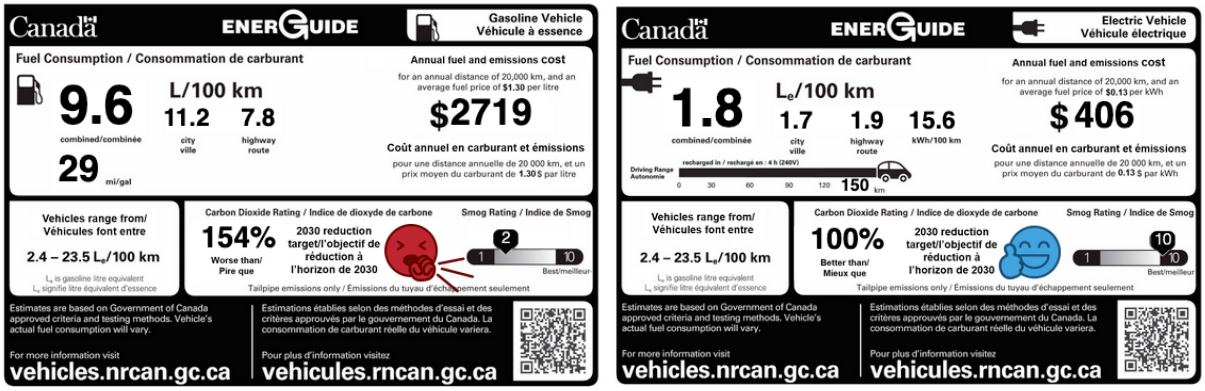
		linked to injunctive			norms.



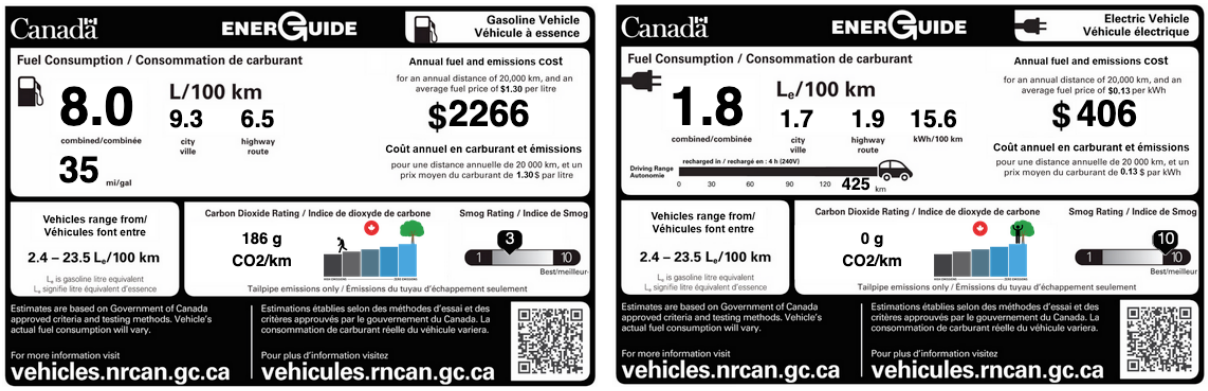
(a) NRCan label (currently used new-vehicle label in Canada) and vehicle choice

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

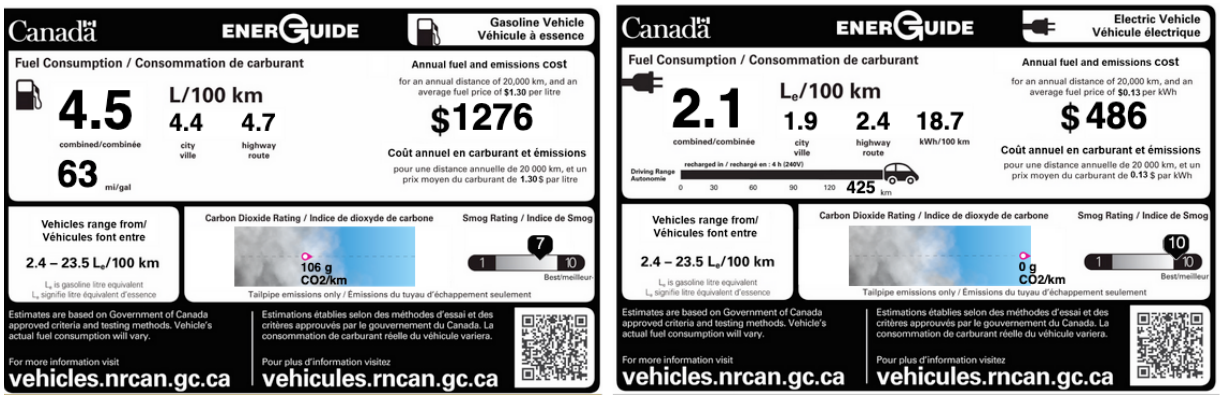
(c) Pressure gauge label and vehicle choice



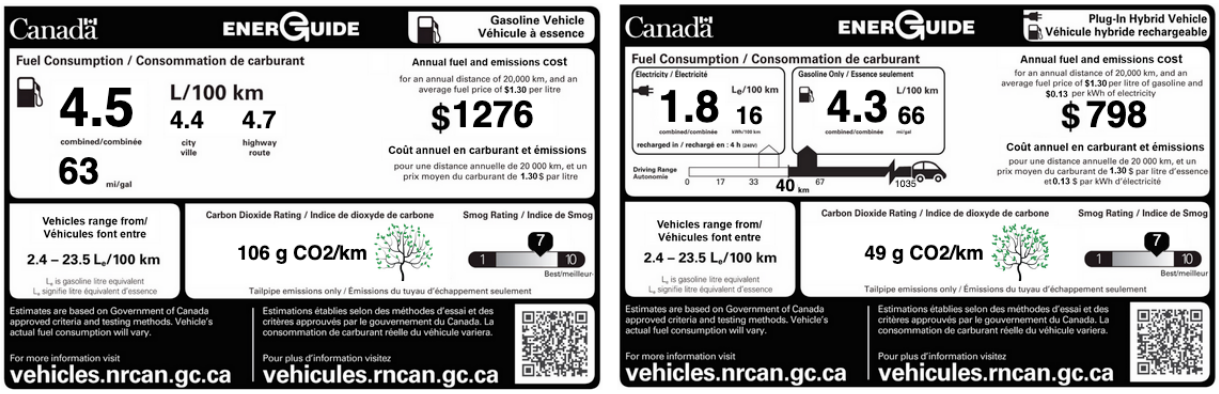
(d) -30% societal goal with new emoticon label and vehicle choice



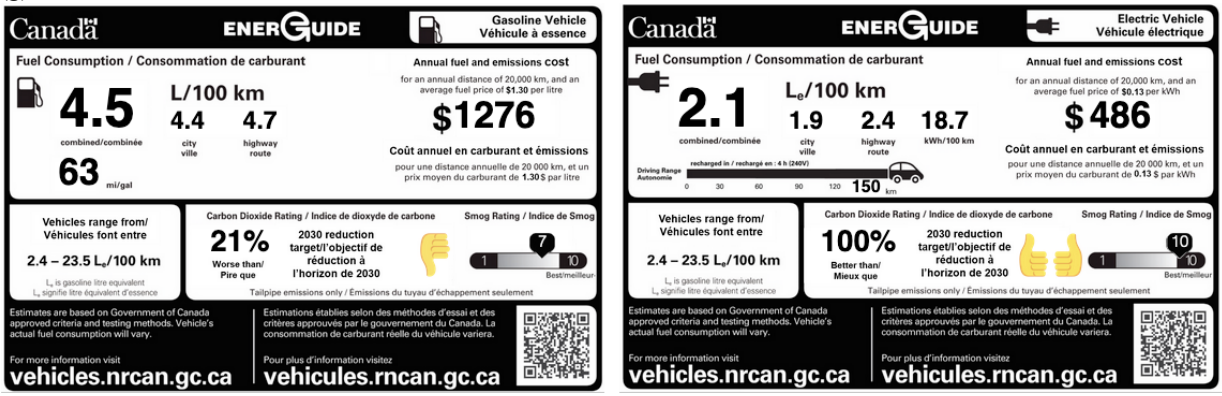
(e) Patriotic goal label and vehicle choice



(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

Fig. 1 The different framings used in this experiment.

(3) Willingness to pay estimate In order to ease the interpretation of the results, the

influence of the framings is estimated using willingness to pay. Details of that approach can be seen in Wang et al., (REF).

3. RESULTS

A simplied choice model was estimate (Table 3). Various results will be discussed.

First, the participants preferred plug-in hybrid electric vehicles (PHEV) over internal combustion engine vehicles (ICEV) and battery electric vehicles (BEV). The range for BEVs had a significant influence, but not the range for PHEV, which likely relates to being able to rely on the gasoline engine.

The CO2 emissions information had a significant influence on choice, but three of new framinings had no statistically different influence than the current NRCan label: dirty-air scale, tree scale, and thumbs up/down. The most effective framing was the new emoji label that incorporates both colour (ranging from blue for clean to dark red for dirtiest) and a dirty air aspect with the most polluting vehicles show a face coughing.

Table 3 Results of choice model.

Name	Point estimate	
ASC_Plug-in hybrid (ref.)	0	
ASC_Electric vehicle	-0.54	***
ASC_Gasoline	-0.491	***
CC-SoC1	-1.03	***
CC-SoC2	-1.13	***
CC-SoC3	-0.418	***
CC-SoC4 (ref.)	0	
CC-SoC5	-0.0709	**
Price (10,000 CA$)	-0.724	***
Discount rate (r) (monthly)	0.017	***
Range_Gasoline (km) (ref.)	0	
Range_Plug-in hybrid (km)	-16.7	
Range_Electric vehicle (km)	11.5	***
CO_2 emissions (kg per month)	0.475	***
NRCan label (ref.)	0	
30% reduction+color	0.203	***
CO_2 emissions (g/km) + Pressure gauge	0.103	**
30% reduction + New emojis	0.429	***
CO_2 emissions (g/km) + Patriotic goal framing	0.129	***
CO_2 emissions (g/km) + Dirty air scale	-0.0333	
CO_2 emissions (g/km) + Tree scale	-0.0134	
30% objective + carbon tax + thumbs up/down	0.0302	
Estimation report		
Number of estimated parameters	18	

Sample size	24144
Init log likelihood	-16735
Final log likelihood	-15031
LR-Test (full model)	3408.46
Rho-square for the init. Model	0.102
Rho-square-bar for the init. Model	0.101
Akaike Information Criterion	30098.2
Bayesian Information Criterion	30243.9

The influence of the information varies considerably by the Climate Change Stage-of-Change measure (Figure 1). People who self identify at the secondest highest CC-SoC were used as the reference category as they were found to be the most motivated. As can be seen in Figure 2, individuals who are either not concerned about climate change or who are concerned but have no intention to reduce their emissions often have a negative willingness-to-pay. Essentially this means that they are willing to pay in order to *produce more* emissions rather than *reduce*. Those individuals represent 24 % of the sample.

The NRCan framing, along with the three framings that are not statistically different, had not measurable effect for people at the CC-SoC of "concerned about climate change, but unsure what to do". However, when a societal context is used, that group had a WTP of $260/tonne of CO2 emissions. If the new emoticon is added, that increases to a WTP of $486/tonne. This group represents 19 % of the sample.

Finally, the top two groups had a WTP of $475/tonne and $404/tonne respectively for the NRCan framing. The previous best framing of the societal framing with colour resulted in WTP of $678/tonne and $607/tonne. The addition of the new emoticon resulted in WTPs of $904/tonne and $833/tonne. Those two groups represent 57 % of the respondents.

5. DISCUSSION

(1) Current results

Consistent with previous findings, the societal framing was found to have a much greater influence on choice than the current NRCan framing. Also consistent with previous findings, the WTP of such information is much greater than the actual carbon tax at the time ($50/tonne).

The previous best framing (societal goal with colour) was improved upon by developing new emojis. Previously, standard emojis from Modzilla (Firefox) were tested and found to be the second best framing (*9*). The newly developed emojis incorporate colour and convey a "dirty air" message. As such, the findings suggest the combination of these techniques is more effective than the singular injunctive norm message through the emojis.

In this experiment, a new CC-SoC was included: people who are concerned, but do not intend to reduce their emissions. They were found to be the least influenced by the CO2 emissions information. Why this might be is not certain, but several hypotheses are presented. One, these individuals simply feel that there is nothing that they can do as individuals. Two, they believe that climate change is happening, but that humans are not responsible for this. Three, they know that climate change is a problem, but either do not want to change their current behavior or feel that they cannot make a change.

Another finding of note is that the respondents prefer PHEVs to both ICEVs and BEVs. A number of reasons likely exist for this. In Canada, urban settlements can be quite far apart and a culture of long "road trips" exists. Having a gasoline engine might reduce the worry of getting stuck in the "middle of nowhere". Canadian winters can be quite severe and batteries often drain faster in such conditions.

(2) Future research

This study tested CO2 emissions framings with Canadians who hold a driver's licence. As such, future work should examine how such framings influence people in other cultures and with the general population.

The current framing is based off of tailpipe emissions, but lifecycle emissions for electric vehicles can be quite large due to the considerable energy (and toxic pollutants) required to produce them. As such, it will be important to know how people react when this more global view is taken.

This experiment tested CO2 emissions framing for new-vehicles, but only considered four-wheel motorized vehicles. Future studies should examine choices between lifecycle emissions of different modes of transport.

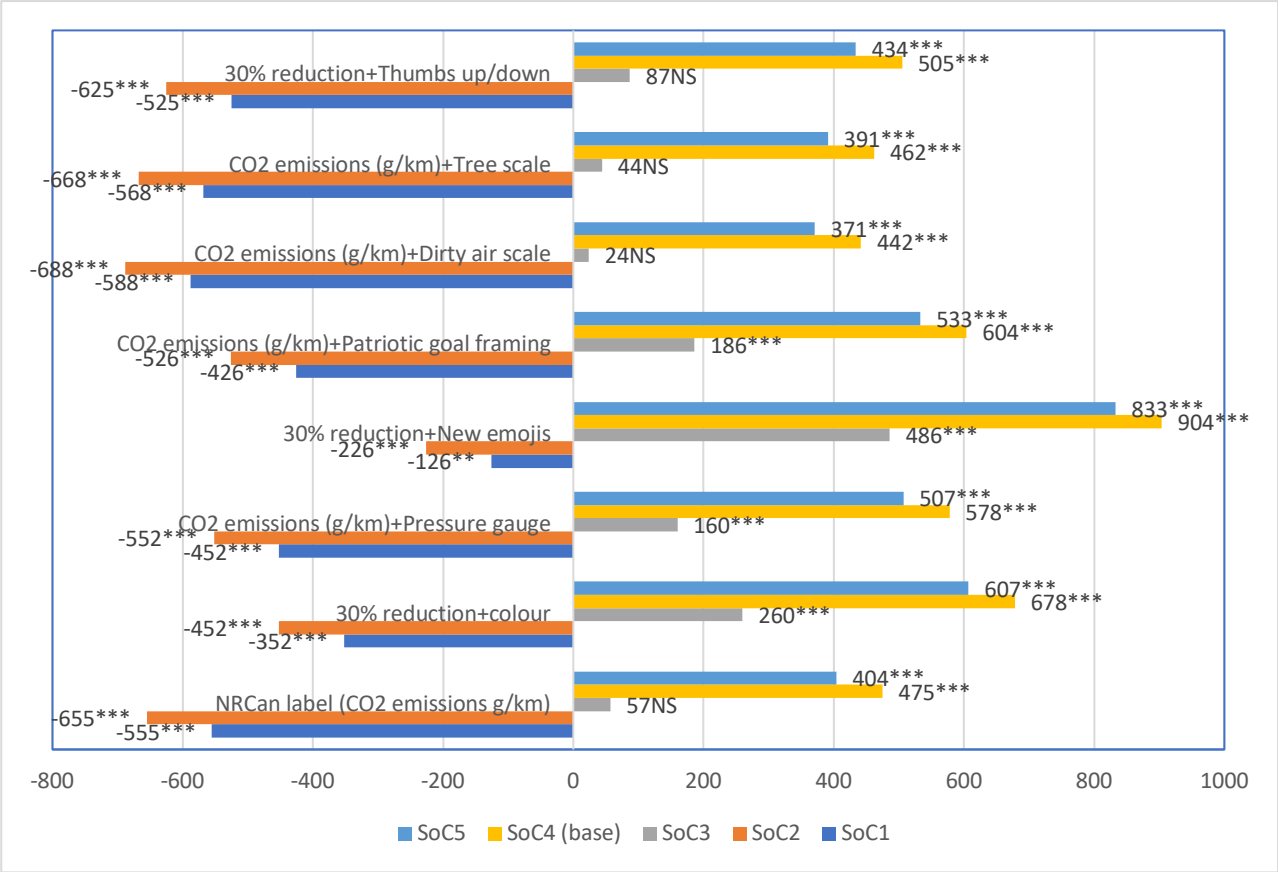


Fig. 2 Willingness to pay for CO2 emissions for different framings by Climate Change Stage-of-Change (SoC).

6. CONCLUSIONS

It is essential to better inform people of how their choices impact our fight against climate change. In this study, we demonstrated that how CO2 emissions information is presented greatly impacts the influence it has on choices. Although some parts of the Canadian sample remain difficult to positively influence, the vast majority of the population was found to be considerably influenced by framing the emissions first by the Canadian Government's GHG emissions reduction target and then adding a newly developed emoji to convey injunctive norms, emotion, and dirty air. The influence on individuals was grouped by their Climate Change Stage-of-Change. For best performing framing the willingness-to-pay was estimated as: 1) - $ 126/tonne; 2) - $226/tonne; 3) $486/tonne; 4) $904/tonne; 5) $833/tonne.

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