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Attribute valence framing to promote pro-environmental transport behavior

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Abstract

The transportation sector constitutes one of the main contributors to CO₂ emissions. Several incentive measures have been already proposed by economists to mitigate these emissions. But, as we all know, these tools have met with mixed success. This paper proposes the use of attribute valence framing, *i.e.* a description of the same object/characteristics positively or negatively, in order to reduce CO₂ emissions. This so-called nudge is easier to implement than more traditional tools, such as taxation, and does not rely on the stringent assumption that individuals are fully rational. The findings from a discrete choice experiment focusing on long-distance travel choice are reported herein. Results indicate that a loss framing on CO₂ emissions significantly increases the respondents' practice of pro-environmental behaviors. The framing effect is larger when applied to CO₂ than to travel duration (+50% and +30% of the willingness to pay, respectively). In employing psychological constructs, it is shown that preferences are affected by individuals' psychological features (*i.e.* a preference for the future and environmental self-identity), and moreover that the magnitude of the framing effect depends on individuals' motivational strategies.

Keywords: Framing effect, Discrete choice experiment, Pro-environmental behavior, Travelers' willingness to pay.

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1 Introduction

The European Union is aiming for climate neutrality by 2050 (i.e. net-zero greenhouse gas emissions). To achieve this goal, a behavioral shift is needed in the transportation sector, which is responsible for a quarter of total emissions (IEA, 2018). Such a shift would lead to low-carbon modes of travel, from private to public transportation, soft mobility or even a reduction in distances traveled. This paper will consider whether attribute valence framing, i.e. a description of the same object/characteristics positively or negatively, could promote pro-environmental transport behavior. One of the main advantages of such framing is that it would be especially simple and inexpensive to set up in the context of a comparison between different travel options.

The literature has increasingly advocated new approaches based on non-price interventions to limit climate change (Stiglitz, 2019). Although the effect of information and communication policies may not be a panacea, past studies have shown that the introduction of a nudge could have a significant impact on behavior. Such a nudge can be defined as "any aspect of the choice architecture that alters individuals' behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein, 2008, p. 6). For instance, Offiaeli and Yaman (2021) revealed that nudging passengers by the use of social norms may be a cost-effective mechanism to reduce dwell times on one of the busiest metro train platform of the London underground. The most well-known type of nudge is probably the framing effect (Tversky and Kahneman, 1981). The framing effect is the measurable impact of selecting of one frame vs. another on decision-making. The framing of a choice with supplementary information about a climate-related topic has already been examined in transport economics through discrete choice experiments (Hilton et al., 2014; Raux et al., 2020). Nevertheless, the type of framing implemented has essentially consisted of information delivered before the choices were made and not within the choice exercise (attribute valence framing). Attribute valence framing is one the three distinct types of valence framing effects (among attribute framing, goal framing and risky choice framing) "in which some characteristic of an object or event serves as the focus of the framing" (Levin et al., 1998). Given the magnitude of CO₂ emissions from the transport sector, it is essential to determine all the types of framing that could encourage individuals to take into account CO₂ emissions in their travel behavior. In particular, it is interesting to be able to estimate the effect of each framing, to allow public authorities to choose the best policies to implement.

To the best of our knowledge, no study has ever tested the impact of the attribute valence framing in the field of transport economics. An example of application would be the choice of the transport mode for a leisure trip (*e.g.* rail vs plane), for which simply giving the emission difference for the long-distance trip could easily be set up in order to increase the perception of the less CO₂-intensive mode. The contribution of our work to the existing literature is threesome: (i) to explore if an easy to implement type of framing could increase pro-environmental behavior in transport choice, (ii) to estimate the effect of this framing, (iii) to analyse if the framing effect could vary according to individual heterogeneity.

We have conducted an online split sample, discrete choice experiment on a national sample of the French population, with a manipulation of the framing of two considered attributes, namely the CO₂ emissions and travel time. We asked a series of follow-up questions in order to evaluate respondents' psychological features. We first observed that preferences are dependent on the underlying psychological features (regardless of framing effects). Using Random Parameter Logit (RPL) models, we then found that individuals with high preferences for the future typically ascribe more

importance to the attributes of travel duration and sanitary measures (i.e. ensuring a one-seat gap), whereas individuals with a high environmental self-identity score are more willing to pay for a decrease in their travel CO₂ emissions and less for a reduction in travel duration. Second, we showed that attribute valence framing as a loss can impact respondents' choices, *ceteris paribus*. The effect of loss framing is greater for the CO₂ emissions attribute than for the travel duration attribute (+50% and + 30% of the willingness to pay (WTP), respectively). Gain framing, on the other hand, does not seem to have any effect. This is a key result of our work, which has yet to be identified in the existing literature.

Lastly, we have sought to assess whether the framing effect depends on individuals' psychological features. We noted that the magnitude of the framing effect depends on individuals' psychological constructs. Those with a low promotion focus score (Higgins, 1997) are strongly affected by loss framing on the CO₂ emissions attribute.

The remainder of this paper is organized as follows. Section 2 provides a brief literature review. Section 3 then describes data collection, the sample's socioeconomic characteristics and the construction of psychological features. Section 4 is devoted to presenting the econometric specification of the models used in this study. Section 5 displays and discusses the results of our analysis, to be followed by a conclusion that considers the potential applications of our results.

2 Contribution to the literature

The use of environmental psychology theory in transport economics research, e.g. modal choice or vehicle choice, is quite recent but has been progressing over the last several decades, in an effort to establish a protocol for efficiently designing environmental policies, especially on the issue of CO₂ emissions reduction (Davison et al., 2014; Giansoldati et al., 2020; Andersson, 2020). The underlying assumption is that an unobservable latent variable, such as environmental consciousness or comfort, can be measured through observable indicators. The structural relations that unite these latent variables are based on structural equation models (Hoyle, 2012). In addition to the contributions from environmental psychology, behavioral economics is another major field that contributes to understanding the choices and patterns in transport economics. In this body of literature, the main theoretical principle relies on the assumption that behavioral preferences do not fully preexist, i.e. they are not fixed as assumed by rational decision theory (Von Neumann and Morgenstern, 1947), but on the contrary are built in the context of the decision-making process as assumed by prospect theory (Kahneman and Tversky, 1979).

Even if some of the research in behavioral economics has addressed transportation issues (Avineri, 2012), only a few studies have ever tested the valence framing effect in the transportation field. In their systematic review of the existing literature on the effects of framing in environmental decisions, Homar and Cvelbar (2021) identified a total of six studies on this topic. For one thing, a majority of them have focused on the effect of goal-framing, i.e. information that emphasizes the potential gain or loss resulting from a certain action, on the behavioral intention to change transportation uses (Arbutnott and Scerbe, 2016; Mir et al., 2016; Moon et al., 2016; Morton et al., 2011). For another, two articles assess how valence framing, i.e. a description of the same object/characteristics positively or negatively, of CO₂ emissions influences the perceived difference in environmental impact, either between two unspecified modes of transport, namely A and B (Avineri and Waygood, 2013), or between two neighborhoods (Waygood and Avineri, 2018). In their experimental condition denoted "positive framing", the quantities of CO₂ emitted by the other mode or

the other neighborhood are displayed as lower. In the experimental condition denoted "negative framing", the quantities of CO₂ emitted by the other mode or the other neighborhood are seen to be higher. These results indicate that the perceived difference between the quantities of CO₂ emitted through transportation is greater for the "negative framing" condition than for the "positive framing" (Avineri and Waygood, 2013), or for "neutral framing" (i.e. no valence framing) (Waygood and Avineri, 2018). Moreover, they are consistent with prospect theory, which states that losses outweigh gains (Kahneman and Tversky, 1979).

Around this same time, the choice experiment method was rarely employed to study framing effects in the field of transportation (Hilton et al., 2014; Raux et al., 2020). Hilton et al. (2014) showed that a bonus-penalty aimed at subsidizing the train by taxing airplane travel had a behavioral effect extending beyond the price effect. For the same fare and depending on the bonus-penalty amounts communicated, the choice of users varied: strengthening of the subsidized choice - the train - at low values, and a crowding-out effect at higher bonus-penalty amounts. Raux et al. (2020) tested various psychological framing to motivate environmentally responsible behavior for long-distance leisure trips. They concluded that all framing effects tested were significant in reducing the intention to choose the most emitting modes. CO₂ information was proven to be very effective and reinforced by an injunctive norm, whereas adding fiscal framing like a carbon tax could be counterproductive compared with solely providing CO₂ information with an injunctive norm. However, the framing effects analyzed in these two articles were essentially information and descriptive norms given before the choice stage and not a direct valence framing on an attribute, as is the case with our study.

Assuming that negative framing of an attribute results in a greater perceived difference (Avineri and Waygood, 2013; Waygood and Avineri, 2018), let's suppose that negative attribute framing has more impact on choice, as compared to either positive attribute framing or neutral framing. Regulatory focus theory (Higgins, 1997) adds to the concept of loss aversion by proposing two distinct motivational strategies regulating all goal-directed behavior. One such strategy, called prevention focus, emphasizes the vigilant avoidance of losses. The other, known as promotion focus, emphasizes the eager pursuit of gains. No research has yet tested the impact of regulatory framing on mode choice. It can be assumed that the choice of a promotion-oriented individual is less influenced by negative attribute framing, compared to positive attribute framing and neutral framing. Mode choice is also affected by psychological constructs like future time perspective (Strathman and Joireman, 2006) and environmental concerns (Bouscasse et al., 2018). The relationship between future time perspective and eco-friendly behavior is typically explained by the temporal dilemma, conveyed by many of our daily choices and behaviors, between short-term and long-term costs and benefits (Van Lange and Joireman, 2008). When considering the future beyond the present, one is able to accept constraints and the efforts needed to achieve future benefits. Participants scoring higher on the "consideration of future consequences" (CFC) scale (Strathman et al., 1994) are more likely to engage in consumer behavior that benefits the environment. Joireman et al. (2004) indicated that higher CFC scores are correlated with the preference to commute to work by means of public transit rather than by car. Environmental self-identity is related to a broad range of environmental behaviors (Van der Werff et al., 2013). We define environmental self-identity as the extent to which one views oneself as a type of person who acts environmentally-friendly. It can thus be assumed that individuals with a high preference for the future and those with a high "environmental self-identity" score ascribe greater importance to CO₂ emissions than to travel time.

3 The survey methodology

A web survey was administered at the end of June 2020 by a professional public opinion research firm, to a representative sample from the French population with respect to age, gender and professional status. A total of 1,032 individuals residing in metropolitan France and aged between 18 and 75 years completed the survey. Administration of the questionnaire lasted less than 15 min. Respondents were assured of the anonymity of their answers. By the time of the survey, coronavirus-related travel restrictions implemented in France after the first lockdown (March 17th - May 10th) had already been lifted.

The questionnaire was structured as follows: (i) basic socio-demographic information, (ii) choice experiment between travel alternatives and (iii) questions regarding psychological features. The questions about socioeconomic background and psychological features were similar for all respondents. In contrast, for the stated preference scenarios, respondents were randomly assigned to one of the five treatments (see Section 3.2).

3.1 Choice experiment

A hypothetical scenario was presented to participants, whereby they needed to travel for a private purpose using public transit. The travel origin and destination of the travel were fixed and not disclosed, and two public transit alternatives were proposed. Since the goal of this study was to analyze the framing effect on attributes, it was essential to avoid the question of transportation mode during the survey, as this would have led to misleading information. The selection of attributes was based on the literature and the specific context of the Covid-19 pandemic, which was a particularly important topic at the time the survey was administered.

To cope with the Covid-19 pandemic, the French government implemented a strict lockdown between March 17th and May 10th, 2020. During this period, virtually no travel was allowed in France in order to reduce social interactions and thus potential contagion. The rules were gradually eased beginning on May 11th. During an initial phase (May 11th - June 1st), travel was only allowed within a 100-km radius of one's residence. Traveling further than 100 km from home required a compelling reason (e.g. frontline work, urgent family reasons) and a specific permit. In public transit systems, non-pharmaceutical measures were implemented (e.g. routine deep cleaning, face masks). In addition, the SNCF national rail company ran on a extremely limited schedule at first, and tickets were restricted to half the seats on the train so as to allow users to comply with social distancing measures. These latter restrictions did not apply to airline companies. As of June 2nd, the 100-km travel limit was lifted and seating restrictions on trains were discontinued; by June 15th, the SNCF was selling tickets for all seats.

The attributes and their associated levels are listed in Table 1. For each quantitative attribute (price, duration, CO₂ emissions), the value can assume one of four possible levels. Conversely, the sanitary measure is a binary variable notifying the presence or absence of a guaranteed one-seat gap between transportation users. More specifically:

1. The **price** of travel (expressed in €), which is the monetary attribute, and one of the main determinants in transportation choice modeling. The possible values of this attribute are: €50, €75, €125, and €175.

2. The travel **duration** (expressed in hours), which is the second unavoidable attribute in transportation choice. This attribute was assigned the following possible values: 3 hrs, 3 hrs 55min, 5 hrs 5 min, and 6 hrs 35 min.
3. **CO₂** emissions (expressed in kg), as the main variable of interest to study the framing effect. It was voluntarily decided not to provide any information on the meaning and/or consequences of a 1-kg emission of CO₂, in order to avoid any unwanted supplementary information framing the effect on this attribute. Moreover, use of the kg unit without offering any further information corresponds to the current practice of the public transit companies. The values associated with this attribute are: 30 kg, 39 kg, 51 kg, and 66 kg.
4. The **sanitary** measure, a binary attribute representing the fact that the transportation operator guarantees a one-seat gap between each passenger. At first, other non-pharmaceutical measures were considered, like the provision of hand sanitizer or face masks. However, the face mask use had already been made mandatory in public transit vehicles, and gel sanitizer could be easily obtained for passengers; hence, provision was already considered as the user’s responsibility. Therefore, the most differentiating sanitary measure between two trips was the guarantee of a one-seat gap between riders. The presence of a one-seat gap as a sanitary measure is determined through a *Yes/No* value.¹

Table 1: Levels of the attributes values of the alternatives.

Attribute	Levels			
Price (€)	50	75	125	175
Duration (min)	180	235	305	395
CO ₂ (kg)	30	39	51	66
Sanitary (One-seat gap)	Yes	No	–	–

3.2 Experimental design

The aim of the experimental design is to construct the choice sets (i.e. combinations of attribute levels) presented to respondents. With four attributes with two to four levels each, the questionnaire would be far too cumbersome if all possible attribute level combinations were given to respondents.

To obtain a choice dataset that yields accurate estimates of the model parameters, one common solution among experimental design techniques consists of using D-efficient designs.² As recommended by Crabbe and Vandebroek (2012), in order to avoid any choice set with a dominant alternative, we used prior information to compute D-efficient designs. In accordance with this principle, a pretest was conducted on a non-representative sample of 48 respondents. An initial D-efficient design was computed for this pretest, which was not subject to any framing effect. A conditional logit model was then estimated in order to obtain prior attribute estimates. These prior

¹This attribute was introduced to take into account the specific sanitary context at the time of the survey. Its detailed analysis will be discussed in a companion paper.

²In order to obtain these designs, the D-optimality criterion, i.e. the determinant of the Fisher information matrix, is maximized. Further details can be found in Louviere et al. (2000).

values were used to generate the final D-efficient design used for the survey.³ Our final experimental design provided 20 different choice sets, with each set being divided into two blocks. Inside each treatment sample, respondents were randomly assigned to one of the two blocks.

The main framing effects studied were the gain and loss on two distinct attributes, i.e. travel time and quantity of CO₂ emitted. The total sample was therefore divided into five treatments: the control group (T1), gain in travel time (T2), gain in CO₂ emissions (T3), loss in travel time (T4), and loss in CO₂ emissions (T5). This same experimental design with 2 groups of 10 choice sets was used for each of the five sub-samples. The only additional manipulation made to the choice sets was that for the two treatments with gain framing (in duration and CO₂). The alternatives with the highest value of the framed attribute were always placed in the first position, whereas they were positioned second for loss framing. An example of a choice set for each treatment is shown in Figure 1.

		Option 1	Option 2
T1 : Control	Time	6h35	3h00
	Cost	€50	€175
	One-seat gap	Yes	No
	CO₂	39 kg	51 kg
		Option 1	Option 2
T2 : Gain in travel time	Time	6h35	3h00 (3h35 less)
	Cost	€50	€175
	One-seat gap	Yes	No
	CO₂	39 kg	51 kg
		Option 1	Option 2
T3 : Gain in CO ₂ emissions	Time	3h00	6h35
	Cost	€175	€50
	One-seat gap	No	Yes
	CO₂	51 kg	39 kg (12 kg less)
		Option 1	Option 2
T4 : Loss in travel time	Time	3h00	6h35 (3h35 more)
	Cost	€175	€50
	One-seat gap	No	Yes
	CO₂	51 kg	39 kg
		Option 1	Option 2
T5 : Loss in CO ₂ emissions	Time	6h35	3h00
	Cost	€50	€175
	One-seat gap	Yes	No
	CO₂	39 kg	51 kg (12 kg more)

Figure 1: Example of the same travel choice set for each of the five treatments.

3.3 Socioeconomic and psychological features

This section will present the descriptive statistics of the respondents' characteristics along with the validation process of the psychological constructs.

³Whereas the first D-efficient design computed for the pretest had two choice sets with a dominant alternative, the one generated with prior values had none.

3.3.1 Socioeconomic characteristics of the sample

Table 2 reports the descriptive statistics of respondents' characteristics. The total sample size of 1,032 is quite representative of the French population of 18 to 75-year-olds in terms of age, gender ratio and professional activity.

Table 2: Selected characteristics of study sample.

Description	French population*	Sample
<i>Gender</i>		
Female	51.1	50.5
Male	48.9	49.5
<i>Age</i>		
Young (18-29)	19.8	21.3
Young adult (30-44)	26.8	27.7
Adult (45-59)	28.6	27.6
Old (60-75)	24.8	23.4
<i>Professional activity</i>		
Top socio-professional category	15.7	18.5
Middle socio-professional category	16.4	14.5
Low socio-professional category	33.7	32.0
Retired	20.0	19.6
Inactive	14.2	15.4
N (ind.)	-	1,032

* Based on census data provided by The National Institute of Statistics and Economic Studies (INSEE).

3.3.2 Comparison of the five sub-samples

The differences between the five sub-samples were tested with a Chi-squared homogeneity test (see Table 3). The p-values below the 5% threshold were considered significant to reject the null hypothesis of no difference between distributions. The five sub-samples can thus be considered as not significantly different for the *Gender*, *Age*, *Net monthly household income (€)* and *Aggravating risk of Covid-19* characteristics.⁴ However, a significant difference is observed between the sample 2 (T2) and the control group (T1) for the *Working situation* and *Education level* variables, as well as between the sample 5 (T5) and the control group (T1) for the *Education level*.

3.3.3 Psychometric variables

The respondents were also asked to express their agreement or disagreement with a series of statements. A five-point Likert scale was used to measure the agreement-disagreement level, with "strongly disagree" coded as 1, "disagree" as 2, "neither agree nor disagree" as 3, "agree" as 4,

⁴The *Aggravating risk of Covid-19* corresponds to the answer (yes or no) to the following question: "Do you think you have any of the risk factors (heart problems, high blood pressure, diabetes, chronic respiratory problems, obesity, cancer, etc.) for severe forms of Covid-19?"

Table 3: Socio-economic characteristics of the five sub-samples.

Description	T1	T2	T3	T4	T5	Chi2 pvalue T1:T2	Chi2 pvalue T1:T3	Chi2 pvalue T1:T4	Chi2 pvalue T1:T5
<i>Gender</i>									
Female	49	49	50	49	55	1.00	0.92	1.00	0.21
Male	51	51	50	51	45				
<i>Working situation</i>									
Active	68	58	68	65	59	0.04	1.00	0.63	0.09
Non active	32	42	32	35	41				
<i>Age</i>									
18-29	22	23	23	18	21	0.22	0.75	0.64	0.96
30-44	26	29	26	31	26				
45-59	28	20	32	28	30				
60-75	23	29	20	22	23				
<i>Education level^a</i>									
E ₁	16	25	19	22	21	0.03**	0.11	0.03**	0.04**
E ₂	42	43	49	48	49				
E ₃	42	31	32	30	30				
<i>Net monthly household income (€)</i>									
<1500	22	19	17	22	20	0.73	0.38	0.88	0.66
1500-3500	53	56	58	51	57				
>3500	24	25	25	27	23				
<i>Aggravating risk of Covid-19</i>									
Yes	76	76	72	76	80	1.00	0.43	1.00	0.35
No	24	24	28	24	20				
N (ind.)	209	207	205	207	204				

Note: *p<0.1; **p<0.05; ***p<0.01

^a E₁: No vocational degree, Basic vocational degree; E₂: Intermediate qualification, Lower tertiary; E₃: Upper tertiary.

and "strongly agree" as 5.⁵ These statements, used to build psychological constructs, were drawn from the environmental and social psychology literature. A total of three constructs were calculated as the mean of their corresponding question scores. All statements used for these constructs are presented in Table 4.⁶

With regard to the psychology literature and given the characteristics of our choice experiment, we adopted the following assumptions:

1. The first construct is the **Consideration of Future Consequences (CFC)**, proposed and validated by Strathman et al. (1994). This score yields a measure of "*the extent to which people consider distant versus immediate consequences of potential behaviors*". The reliability

⁵As shown in Table 4, Questions 3, 4, 9, 10, 11 and 12 were asked in reverse order compared to their respective score, as performed in the reference studies. The Likert-scale of the pertinent questions was thus inverted before coding.

⁶The original statements in French are available upon request submitted to the authors.

of CFC was proven through various experiments demonstrating its ability to predict several environmental and health behaviors. It can thus be expected that this construct would be linked to the estimated CO₂ coefficients of the discrete choice model. We used a French adaptation and validation of the Consideration of Future Consequences scale (Demarque et al., 2010).

2. The concept of regulatory focus, introduced by Higgins (1997), distinguishes two motivational strategies regulating goal-directed behavior, namely promotion and prevention. On the one hand, a Promotion focus emphasizes the pursuit of gain (or avoidance of non-gain) along with aspirations toward ideals with eager means, by means of adopting additive tactics. On the other, a Prevention focus is driven by safety and responsibilities. These two constructs are especially interesting for analyzing the heterogeneity of framing effects in gains and losses between respondents. The underlying hypothesis is that a strong **Promotion focus** (resp. **Prevention focus**) leads to a higher (resp. lower) sensitivity to a gain framing, and to a lower (resp. higher) sensitivity to a loss framing. We introduced a French translation of a composite measure of five regulatory focus measures (Haws et al., 2010).
3. In order to evaluate environmental preferences, intentions and their correlation with the CO₂ attribute, the **Environmental self-identity** score (hereafter denoted Identity) was estimated (Van der Werff et al., 2013). Self-identity is defined as the extent to which one sees oneself as a type of person who acts in an environmentally-friendly manner. This construct is especially relevant in explaining pro-environmental actions, rather than merely the importance of the environment in and of itself. A positive correlation is therefore expected to be found between this score and the importance of the CO₂ coefficient in the discrete choice model.

Table 4: Questions used for psychological constructs.

Constructs	Statements
Consideration of Future Consequences	
Q1	I consider how things might be in the future, and try to influence those things with my day to day behavior.
Q2	Often I engage in a particular behavior in order to achieve outcomes that may not result for many years.
Q3	I only act to satisfy immediate concerns, figuring the future will take care of itself.
Q4	My behavior is only influenced by the immediate (i.e. a matter of days or weeks) outcomes of my actions.
Q5	My convenience is a big factor in the decisions I make or the actions I take.
Q6	I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.
Q7	I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.
Q8	I think it is more important to perform a behavior with important distant consequences than a behavior with less-important immediate consequences.
Q9	I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.
Q10	I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.
Q11	I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date.
Q12	Since my day to day work has specific outcomes, it is more important to me than behavior that has distant outcomes.
Promotion	
Q13	When it comes to achieving things that are important to me, I find that I don't perform as well as I ideally would like to do.
Q14	I feel like I have made progress toward being successful in my life.
Q15	When I see an opportunity for something I like, I get excited right away.
Q16	I frequently imagine how I will achieve my hopes and aspirations.
Q17	I see my self as someone who is primarily striving to reach my "ideal self" - to fulfill my hopes, wishes, and aspirations.
Prevention	
Q18	I usually obeyed rules and regulations that were established by my parents.
Q19	Not being careful enough has gotten me into trouble at times.
Q20	I worry about making mistakes.
Q21	I frequently think about how I can prevent failures in my life.
Q22	I see myself as someone who is primarily striving to become the self I "ought" to be - fulfill my duties, responsibilities and obligations.
Identity	
Q23	Acting environmental friendly is an important part of who I am.
Q24	I am the type of person who acts environmental friendly.
Q25	I see myself as an environmental-friendly person.

In order to verify the internal consistency of the psychological constructs, Cronbach's α coefficients were computed (Cronbach, 1951). The typical minimum threshold of 0.7 was used to validate the internal coherence of the questions contributing to the score. The values, shown in Table 5, indicate that three scales (i.e. CFC, Promotion (without Q13) and Identity) are indeed internally consistent and reach acceptable Cronbach's alpha levels, whereas Prevention is insufficiently reliable. Consequently, in the following discussion, we will use these three psychological constructs to describe

the individuals' psychological features.⁷

Table 5: Constructs validity (Cronbach's alpha coefficient).

Score	Question numbers	Cronbach's α
CFC	Q1 to Q12	0.70
Promotion	Q13 to Q17	0.63
Promotion (without Q13)	Q14 to Q17	0.72
Prevention	Q18 to Q22	0.62
Identity	Q23 to Q25	0.91

Table 6 reports the mean and standard deviation of the three remaining psychological constructs for each sub-sample (i.e. each round of treatment). Welch's tests were performed between all sub-samples' psychological constructs in order to identify potential significant selection bias with psychological features. For each of the four framed samples and each constructed psychological construct, the null hypothesis of mean equality with the control group was tested. No significant mean difference was found between each sub-sample and the control group (see Table 7). For the remainder of this article, the three psychological constructs were standardized to facilitate the estimation of their effect using econometric models.

Table 6: Psychological construct means and standard deviations by treatment.

Score	T1		T2		T3		T4		T5	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
CFC	3.39	0.50	3.35	0.50	3.34	0.47	3.35	0.48	3.37	0.49
Promotion	3.58	0.68	3.54	0.73	3.55	0.65	3.54	0.73	3.54	0.64
Identity	3.89	0.79	3.83	0.79	3.72	0.78	3.81	0.76	3.90	0.75
N (ind.)	209		207		205		207		204	

Table 7: Welch test p-values between psychological constructs' framed samples and the control group (T1).

Score	Welch test p-values			
	T1:T2	T1:T3	T1:T4	T1:T5
CFC	0.38	0.40	0.40	0.68
Promotion	0.50	0.57	0.57	0.54
Identity	0.46	0.30	0.30	0.91

Note: *p<0.1; **p<0.05; ***p<0.01

⁷We dropped Q13 from the calculation of the Promotion score in order to improve Cronbach's α from 0.63 to 0.72.

It is thus possible to analyze the general effect of psychological constructs on the full sample (i.e. aggregation of the five sub-samples). In this case, the absolute value of the estimated coefficients differs from the one stemming from a non-framed sample, although this is not a problem. The objective herein is to have a large enough sample size to obtain robust values of the general effect of psychological constructs on respondents' willingness to pay (WTP) for the various attributes.

4 Econometric approach

For the analysis conducted in this paper, we have used both random parameter logit models and a WTP-space approach to analyze the responses to discrete choice experiment questions.

4.1 Random Utility Model in a discrete choice experiment

The choice experiment modeling framework relies on Lancaster's characteristics of value theory (Lancaster, 1966) as well as random utility theory (McFadden, 1974). Since a good may be described by a set of characteristics, its value becomes the sum of the values of all its characteristics. According to the discrete choice experiment approach, an alternative $i \in \llbracket 1; I \rrbracket$ can then be described by a set of K observable characteristics, called attributes, as denoted by $X_i = (x_{i,1}, \dots, x_{i,k}, \dots, x_{i,K})'$. An individual $n \in \llbracket 1; N \rrbracket$ is described by A economic and attitudinal characteristics, called socio-economic variables, denoted $Z_n = (z_{n,1}, \dots, z_{n,a}, \dots, z_{n,A})'$. The (indirect) utility $V_{n,i}$ is thus given by:

$$V_{n,i} = V(X_i, Z_n) \text{ for } n \in \llbracket 1; N \rrbracket \text{ and } i \in \llbracket 1; I \rrbracket \quad (1)$$

McFadden (1974) considered that individuals make choices according to a deterministic component based on both their measured characteristics Z and attribute alternatives X , along with some degree of randomness ϵ . The random utility $U_{n,i}$ of an alternative $i \in \llbracket 1; I \rrbracket$ for respondent $n \in \llbracket 1; N \rrbracket$ is therefore composed of a deterministic part, i.e. the (indirect) utility $V_{n,i} = V(X_i, Z_n)$, and the stochastic element, $\epsilon_{n,i}$, thereby capturing the unsystematic and unobserved random element of respondent n 's choice (Louviere et al., 2000).

$$U_{n,i} = V(X_i, Z_n) + \epsilon_{n,i} \quad (2)$$

According to Equation (2), the random utility $U_{n,i}$ is composed of a deterministic component, $V_{n,i} = V(X_i, Z_n)$, and a stochastic element, $\epsilon_{n,i}$. Before estimating an econometric model, the deterministic part of the utility function $V_{n,i} = V(X_i, Z_n)$ must be specified. The linear specification is often chosen in the literature for the sake of simplicity. We have thus introduced the column vector of parameters $\beta_n = (\beta_{1,n,i}, \dots, \beta_{K,n,i})$, which are the coefficients quantifying the (linear) influence of the K attributes on utility that individual n associates with the I available alternatives.

An Alternative Specific Constant (ASC) term is usually introduced to capture the effect of unobserved influences (i.e. omitted variables) on the utility function. It is a dummy variable assuming a value 1 if none of the hypothetical alternatives is chosen (i.e. selection of the status quo alternative), and 0 otherwise. In its most general form, the model is specified such that the utility of an alternative is expressed as follows:

$$U_{n,i} = (\eta_i + \phi_{n,i}Z_n)ASC_i + \beta_{n,i}X_i + (X_i)' \Gamma_i Z_n + \epsilon_{n,i} \quad (3)$$

where $\phi_{n,i} = (\phi_{n,i,1}, \dots, \phi_{n,i,A})$ are the coefficients representing the direct influence of the A socioeconomic and psychological variables on the utility of the N individuals for alternative I . The matrix Γ_i of size $(K \times A)$, is composed of coefficients $\gamma_{i,k:a}$; it serves to capture the effect of individuals' characteristics $z_{n,a}$ on attribute $x_{i,k}$.

When alternatives are unlabeled, the choice options given are thus symmetrical, differing only in the attributes assigned X_i . Even if a reference choice bias were to exist, it could be represented by a simple Alternative Specific Constant. Therefore, the previous coefficients $\beta_{n,i}$, $\phi_{n,i}$ and Γ_i do not depend on alternative i ; they can be simplified into β_n , ϕ_n and Γ . Let's observe that for each individual, $\phi_n Z_n$ remains constant across all alternatives i and therefore does not influence the model; hence, this item can be removed, yielding:

$$U_{n,i} = \beta_n X_i + (X_i)' \Gamma Z_n + \epsilon_{n,i} \quad (4)$$

4.2 Random Parameter Logit Model

While the Conditional Logit (CL) model is a cornerstone for analyzing discrete choice data and has been widely used in discrete choice experiments, nonetheless it displays several well-known limitations. Two major drawbacks are: 1) it assumes homogeneous preferences across respondents, and 2) it relies on the hypothesis of the independence of irrelevant alternatives (*IIA*).⁸

Compared to the CL model, the Random Parameter Logit (RPL) model (McFadden and Train, 2000; Train, 2009) relaxes the *IIA* hypothesis and is able to take the heterogeneity of preferences into account. Indeed, the preferences parameters β are allowed to vary randomly across respondents, in allowing for the fact that different decision-makers may have different preferences: $\beta_n \neq \beta_m \quad \forall n \neq m$; $(n, m) \in \llbracket 1; N \rrbracket^2$. As such, conditional on the individual-specific parameters and error components, we can define the logit probability that respondent n chooses a specific alternative i for a given β :

$$P_{n,i} | \beta = L_{n,i}(\beta) = \frac{e^{V_{n,i}(\beta)}}{\sum_j e^{V_{n,j}(\beta)}} \quad (5)$$

Without taking into account the cross-effects of socio-demographic characteristics, the individual specific utility is simply modeled by:

$$U_{n,i} = \beta_n X_i + \epsilon_{n,i} \quad (6)$$

where $\epsilon_{n,i} \sim \text{iid extreme value type I}$, and $\beta_n \sim g(\beta | \Omega)$.

Since β_n is not known, the unconditional choice probability of person n choosing alternative i is the integral of $P_{n,i} | \beta$ over the distribution of β :

$$P_{n,i} = \int L_{n,i}(\beta) f(\beta | \Omega) d\beta \quad (7)$$

$f(\beta | \Omega)$ is the density describing the distribution of preferences across individuals. Ω is a vector of the true parameters of the taste variation, e.g. fixed parameters of the distribution representing the mean and standard deviation of β_n within the population. The true distribution remains unknown,

⁸The hypothesis of irrelevant alternatives implies that the relative probabilities of two options being chosen are unaffected by the introduction or removal of other alternatives.

so, in theory, any distribution could be applied (Hensher and Greene, 2003). It is commonly assumed in the literature that random parameters are normally distributed.

4.3 WTP-space approach

In their seminal paper, Train and Weeks (2005) found that the WTP distributions they derived from preference models had an “unreasonably” large variance in comparison with WTP distributions derived from utility models in the WTP-space. This result has been confirmed in subsequent studies (Mabit et al., 2006; Scarpa et al., 2008; Rose and Masiero, 2010). According to the WTP-space approach, marginal WTP estimates are directly obtained, unlike with the preference space approach, where a ratio is to be computed between the non-cost attribute and the cost attribute.

Equation 4 corresponds to the preference space model. The willingness to pay for an attribute $k \in \llbracket 1; K - 1 \rrbracket$ equals the ratio of the attribute’s coefficient to the price coefficient:⁹

$$WTP_{k,n} = \frac{\beta_{k,n}}{-\beta_{p,n}}$$

With this definition, utility (without considering any socio-demographic characteristic effects) can be rewritten in the WTP-space as follows:

$$U_{n,i} = \beta_{p,n}x_{p,i} + \beta_{p,n} \sum_{k=1}^{K-1} WTP_{k,n}x_{k,i} + \epsilon_{n,i} \quad (8)$$

When adding the effects of psychological features or socioeconomic characteristics, it is necessary for all $\gamma_{k:a}$ (which measure the effects of individuals’ characteristics on attribute preferences) to be divided by the price coefficient $\beta_{p,n}$ in order to generate their estimation in the WTP-space. The newly formed $\gamma_{k,a}$ ¹⁰ in the WTP-space therefore measure the effect of the socio-demographic characteristic $z_{a,n}$ on the WTP for attribute k . It is possible to consider these effects as being directly included in individuals’ WTP so as to facilitate model interpretation. The WTP is now defined as follows:

$$WTP_{k,n} = WTP_{base,k,n} + \sum_{a=1}^A \gamma_{k,a}z_{a,n} \quad \text{with} \quad WTP_{base,k,n} = \frac{\beta_{k,n}}{-\beta_{p,n}} \quad (9)$$

Equation 8 then becomes:

$$U_{n,i} = \beta_{p,n}x_{p,i} + \sum_{k=1}^{K-1} \left(WTP_{base,k,n} + \sum_{a=1}^A \gamma_{k,a}z_{a,n} \right) x_{k,i} + \epsilon_{n,i} \quad (10)$$

5 Empirical results

This section is organized as follows. We will first analyze how respondents’ psychological constructs (Consideration of Future Consequences and Environmental Self-identity) may impact their

⁹The price is considered to be the last attribute, for purpose of consistency with the previous notations.

¹⁰We have opted to maintain the same variable for the effect of the individuals’ characteristics in both the preference and WTP-space in order to simplify notations.

preferences, without considering any framing effects. This analysis is achieved with an RPL model including cross-effects. Second, framing effects will be analyzed through an RPL model with a dummy variable for each treatment. Last, the Promotion score will be used to identify individual heterogeneity in the magnitude of framing effects.

5.1 Psychological effects

A Random Parameter Logit in the WTP-space is first estimated on the total sample of 1,032 individuals, yet without including any framing effect or psychological constructs. The random utility model used is the one described by Equation 8. The mixed effect of the RPL model is specified with a normal distribution for the price coefficient ($\beta_{price,n} \sim \mathcal{N}(\mu_{price}, \sigma_{price})$), as well as with a normal distribution for the duration, CO₂ emissions and sanitary measure, i.e. WTPs ($WTP_{k,n} \sim \mathcal{N}(v_k, \sigma_k)$ for the $k \in \{duration, co_2, sanitary\}$). This set-up serves as a reference estimation for WTP and price coefficients to verify the robustness of the subsequent models with psychological constructs and framing effects. As shown in Table 8 (Model 1), all the coefficients are significant with a 1% p-value threshold, indicating that all the attributes are taken into account in the average of individuals. The signs of the four attributes are consistent: the positive sign of the mean WTP for duration, CO₂ emissions and sanitary measure is consistent. As expected, the price coefficient is negative. Individuals are willing to pay, on average, €0.27 to decrease their travel time by 1 minute, and €0.56 to decrease the emissions of their trip by 1 kg of CO₂. On the other hand, they are willing to pay €23.20 to benefit from a guaranteed one-seat gap.

As described in Section 4.3, the effect of psychological constructs on each WTP can be estimated through cross-effects. We therefore introduced into the WTP equation for each attribute (duration, CO₂ and sanitary measure) the effect of the individual psychological constructs CFC and Identity:

$$WTP_{k,n} = WTP_{base,k,n} + \gamma_{CFC:k} \times CFC_n + \gamma_{Identity:k} \times Identity_n \quad (11)$$

for $k \in \{duration, co_2, sanitary\}$

with $\gamma_{CFC:k}$ (resp. $\gamma_{Identity:k}$) denoting the effect of the individual's CFC (resp. Identity) score on the WTP for attribute k .

The results of the corresponding model are presented in Table 8 (Models 2 and 3). They show that both constructed scores have a significant effect on travel attributes. Individuals with a high preference for the future (CFC) generally ascribe more importance to the *duration* and one-seat gap *sanitary* measure attributes.¹¹ Individuals with a high environmental self-identity score exhibit a higher preference for the CO₂ emissions attribute and a lower preference for travel *duration*. For instance, given our results and respondents' psychological constructs, the average willingness to pay for duration ($WTP_{duration}$) of the 25% of individuals with the lowest CFC scores would be nearly half that of the 25% of individuals with the highest CFC scores (€0.18/min vs. €0.29/min). When examining the 25% of individuals with respectively the lowest and highest Identity scores, we observe a significant difference in average willingness to pay for CO₂ (WTP_{co_2}) between these two groups (i.e. €0.19/kg CO₂ vs. €0.70/kg CO₂).

Our results are consistent with most of the hypotheses previously forwarded on psychological constructs (see Section 3.3.3):

¹¹More precisely, an increase by 1 standard deviation serves to increase, on average, by €0.034 the WTP for a 1-minute shorter trip, and by €4.82 the WTP for having a guaranteed one-seat gap.

Table 8: RPL model based on psychological constructs.

Variable	(1)	(2)	(3)
$v_{duration}$	0.2644*** (0.016)	0.256*** (0.018)	0.2535*** (0.018)
v_{co_2}	0.5634*** (0.060)	0.5613*** (0.062)	0.5591*** (0.062)
$v_{sanitary}$	23.2476*** (1.987)	22.8468*** (2.099)	22.7622*** (2.094)
μ_{price}	-0.0486*** (0.003)	-0.0509*** (0.003)	-0.0511*** (0.003)
$\sigma_{duration}$	0.4084*** (0.019)	0.3893*** (0.019)	0.3896*** (0.019)
σ_{co_2}	1.0753*** (0.069)	1.075*** (0.068)	1.0711*** (0.068)
$\sigma_{sanitary}$	51.8477*** (2.205)	50.7706*** (2.233)	50.6545*** (2.245)
σ_{price}	0.0297*** (0.002)	0.0345*** (0.003)	0.0349*** (0.004)
$\gamma_{CFC:duration}$	—	0.0435** (0.018)	0.0343** (0.017)
$\gamma_{CFC:co_2}$	—	0.0281 (0.063)	—
$\gamma_{CFC:sanitary}$	—	4.9341** (2.125)	4.82** (2.105)
$\gamma_{Identity:duration}$	—	-0.0291 (0.018)	—
$\gamma_{Identity:co_2}$	—	0.2063*** (0.064)	0.2163*** (0.061)
$\gamma_{Identity:sanitary}$	—	-5.8021*** (2.073)	-6.0828*** (2.037)
N (ind.)	1,032	1,032	1,032
Log Likelihood	-5338.301	-5314.118	-5315.572
AIC	10692.6	10656.24	10655.14
BIC	10750.54	10757.62	10742.05

Note: *p<0.1; **p<0.05; ***p<0.01

1. The CFC (Consideration of Future Consequences) construct provides information on individuals' preferences for duration and sanitary attributes. The fact that individuals with a strong preference for distant versus immediate consequence-driven behavior assign greater importance to the sanitary attribute is especially interesting. One interpretation of this result is that the consequence of self-exposure to a Covid-19 risk is mostly considered as temporally distant. This finding could be explained by the high degree of uncertainty regarding virus contraction and symptoms, as well as by the incubation period before the onset of virus effects (compared to the direct consequences of numerous day-to-day risky behaviors). The other outcome is that a higher *CFC* score leads to a higher *duration* coefficient. This somewhat

counter-intuitive result is difficult to interpret.

2. The effect of environmental self-identity on the co_2 coefficient follows the expected trend, with an increase in the coefficient value for a higher Identity score. This effect is quite significant when comparing the co_2 coefficient for the baseline, v_{co_2} , with the coefficient for the effect, $\gamma_{Identity:co_2}$. The duration effect could be considered as a counterpart to the CO₂ effect. *Identity* also has a negative effect on the *sanitary* attribute, i.e. individuals with high environmental self-identity are less concerned with sanitary measures in transportation.

5.2 Framing effects

We have shown that psychological features, when build into psychological constructs, exert an effect on travel choice. Let's now analyze how attribute framing can modify these preferences. The average effect of the four treatments will first be estimated. Then, it will be investigated how a psychological constructs specifically designed to measure gain or loss sensitivity can impact these average preferences.

5.2.1 Average framing effect on attributes

To estimate the framing effect directly on the WTP-space, dummies of the framed attributes were introduced into the previous model. The utility remains the same as in Equation 9, considering framing as an individual's characteristic. Two dummy variables, $T2_n$ and $T4_n$, were introduced to estimate the effect of the duration framing on the mean of the baseline distribution of $WTP_{duration}$. The same was carried out on $T3_n$ and $T5_n$ for WTP_{co_2} , thus yielding the following equations:

$$WTP_{duration,n} = WTP_{base,duration,n} + \gamma_{duration:T2} \cdot T2_n + \gamma_{duration:T4} \cdot T4_n \quad (12)$$

$$WTP_{co_2,n} = WTP_{base,co_2,n} + \gamma_{co_2:T3} \cdot T3_n + \gamma_{co_2:T5} \cdot T5_n \quad (13)$$

with $WTP_{base,duration,n}$ (resp. $WTP_{base,co_2,n}$) following a normal distribution, and $\gamma_{k:t}$ representing the effect of the framing effect $t \in \{T2, T3, T4, T5\}$ on the WTP mean for attribute k .

The results of the RPL model are reported in Table 9 (Models 4 and 5). It can be observed that only $\gamma_{duration:T4}$ and $\gamma_{co_2:T5}$ are significant at the 10% level, as opposed to $\gamma_{duration:T2}$ and $\gamma_{co_2:T3}$, which are not significant (Table 9, Model 4). This indicates that the loss framing in duration (resp. in CO₂ emissions) is significant and moreover increases the average preference for shorter trip duration (resp. lower CO₂ emissions). Table 9 (Model 5) thus presents the reduced model, i.e. without $\gamma_{duration:T2}$ and $\gamma_{co_2:T3}$. For one thing, the baseline WTP for travel duration equals to €0.24/min, and the loss framing on duration increases this baseline by €0.08/min (for a 32% increase). For another, the baseline WTP for CO₂ equals to €0.49/kg and the loss framing on CO₂ adds €0.26/kg to this value (52% increase). This result shows that loss framing on CO₂ produces a larger effect than loss framing on duration, relative to their average baseline values.

As a first result, this analysis shows that only loss framing treatments have a significant impact compared to the control group. The additional information given, namely a drop in travel time, significantly increases the WTP to reduce travel time, whereas information showing lower CO₂ serves to increase the WTP to reduce CO₂ emissions. No significant effect on the corresponding attribute can be observed with the two gain framing treatments. This is in line with the systematic literature review conducted by Homar and Cvelbar (2021), who revealed that loss framing is more

Table 9: RPL models with framing effects.

Variable	(4)	(5)	(6)
$v_{duration}$	0.2432*** (0.022)	0.2409*** (0.020)	0.2412*** (0.020)
v_{co_2}	0.47*** (0.080)	0.4864*** (0.071)	0.4894*** (0.071)
$v_{sanitary}$	23.7405*** (2.099)	23.7759*** (2.099)	23.9041*** (2.088)
μ_{price}	-0.0507*** (0.003)	-0.0506*** (0.003)	-0.0504*** (0.003)
$\sigma_{duration}$	0.3913*** (0.019)	0.3918*** (0.019)	0.3933*** (0.019)
σ_{co_2}	1.079*** (0.070)	1.0806*** (0.070)	1.0729*** (0.071)
$\sigma_{sanitary}$	51.8644*** (2.291)	51.9013*** (2.294)	51.995*** (2.304)
σ_{price}	0.0345*** (0.004)	0.0343*** (0.004)	0.0339*** (0.004)
$\gamma_{duration:T2}$	-0.0116 (0.044)	—	—
$\gamma_{duration:T4}$	0.0749* (0.041)	0.0776** (0.039)	0.076* (0.040)
$\gamma_{co_2:T3}$	0.0662 (0.163)	—	—
$\gamma_{co_2:T5}$	0.2729* (0.159)	0.2567* (0.154)	0.2475 (0.155)
$\omega_{duration:T4:Promotion}$	—	—	0.0531 (0.033)
$\omega_{co_2:T5:Promotion}$	—	—	-0.3176** (0.153)
N (ind.)	1,032	1,032	1,032
Log Likelihood	-5,330.927	-5,331.042	-5,327.649
AIC	10,685.85	10,682.08	10679.3
BIC	10,772.76	10,754.5	10,766.2

Note: *p<0.1; **p<0.05; ***p<0.01

successful than gain framing in inducing changes in the willingness to pay for pro-environmental behavior. This furthermore underscores the importance of the way information about a choice is actually delivered, with the focus on loss being able to modify an individual's choice. The weakness of gain framing compared to loss framing can be tied to prospect theory (Kahneman and Tversky, 1979), whereby the value function is steeper for losses than for gains. In this case, it is more relevant to refer to the generalized version of this theory for riskless choices, i.e. the theory of consumer choice (Tversky and Kahneman, 1991).

The second result states that the effect of the loss framing on the CO₂ attribute is stronger than on the duration attribute, when compared to their respective value in the absence of framing. This

result could be explained by the complexity of the CO₂ attribute compared to duration; it may also be due to the fact that the baseline preference for lower CO₂ emissions would be smaller than that for travel duration. Regardless of the explanation, this result clearly indicates that a loss framing in CO₂ has a relatively stronger effect than framing on a common and well understood attribute like duration. In considering the strength of this relative effect (about +50%), it is further emphasized that loss framing on CO₂ emissions is a relevant option in order to favor pro-environmental transport behavior.

5.2.2 Psychological influence on the framing effect

The following objective is to determine if the framing effect is influenced by individual’s psychological constructs. For this purpose, we have investigated whether or not the framing can vary according to the heterogeneity of the Promotion score. The working hypothesis is that a strong Promotion focus would lead to greater sensitivity for gain framing, and lower sensitivity for loss framing. As previously noted, gain framing for both duration and CO₂ is not significant, thus rendering irrelevant the need to explore the heterogeneity of preferences within treatments T2 and T3. Consequently, our focus is limited to the loss framing applied to travel duration (T4) and CO₂ emissions (T5).

In seeking to determine whether the impact of the framing effect on coefficient attributes varies for individuals with different psychological features, three types of variables (attributes, treatments and psychological constructs) must be cross-analyzed. As explained in Section 4.1, for a non-labeled choice experiment, this requirement can be taken into account in the Random Utility Model (RUM) through interaction terms. The utility equation is similar to Equation 9, but the difference lies in Promotion heterogeneity, which gets added to the average framing effects $\gamma_{duration:T4}$ and $\gamma_{co2:T5}$.

$$WTP_{duration,n} = WTP_{base,duration,n} + (\gamma_{duration:T4} + \omega_{duration:T4:Promotion} \times Promotion_n).T4_n \quad (14)$$

$$WTP_{co2,n} = WTP_{base,co2,n} + (\gamma_{co2:T5} + \omega_{co2:T5:Promotion} \times Promotion_n).T5_n \quad (15)$$

where $Promotion_n$ is the Promotion score of individual n , and $\omega_{duration:T4:Promotion}$ (resp. $\omega_{co2:T5:Promotion}$) represents the impact of the individual’s Promotion score on the average framing effect.

The results (Table 9, Model 6) show a significant effect for $\omega_{co2:T5:Promotion}$, but not for $\omega_{duration:T4:Promotion}$, meaning that the strength of individuals’ Promotion focus does not influence the framing effect on the duration attribute. In contrast, individuals with a strong Promotion focus are less sensitive to a loss framing on the CO₂ emissions attribute. Indeed, $\omega_{co2:T5:Promotion}$ is equal to -0.32 which can be interpreted as follows: with all other things being equal, an individual with a Promotion focus of 1 standard deviation higher is affected by loss framing with a total effect on the WTP equal to -€0.07/kg CO₂, which suggests that individuals with a high Promotion focus are not affected by loss framing on CO₂.¹² Conversely, individuals with a low Promotion score are even more strongly affected by loss framing on CO₂. The magnitude of the framing effects is therefore dependent on the individuals’ motivational strategies. For instance, given our respondents’ characteristics, the average willingness to pay for CO₂ (WTP_{co2}) of the 25% of individuals with the

¹²This interpretation constitutes a simplification, in assuming a linear effect of the score on the framing effect, which most likely is not true.

lowest Promotion scores would be nearly three times higher than for the 25% of individuals with the highest Promotion scores (€1.23/min and €0.44/min respectively).

6 Discussion and Conclusion

The primary focus of this paper has been to determine, for the first time, how attribute valence framing could contribute to influencing travel choices. We thus conducted a discrete choice experiment with gain and loss framing on two attributes: travel duration and CO₂ emitted during trip-making. A comparison of individuals' estimated WTP, including treatment effect, showed that loss framing has a positive effect on the individuals' preference for the framed attribute, whereas gain framing does not seem to exert any significant effect. These results are consistent with prospect theory, according to which the value function is steeper for losses than for gains. They underpin previous findings in the field of transportation (Avineri and Waygood, 2013; Waygood and Avineri, 2018), by demonstrating that loss framing on an attribute more heavily impacts travel choice in a discrete choice experiment, as compared to gain framing or no framing.

In addition to primary result, we sought to determine whether some psychological features could affect transportation choice behavior by using three psychological constructs from the psychological literature (Consideration of Future Consequences, Promotion, and Environmental self-identity), which were validated herein with Cronbach's α coefficients. We showed that in ignoring the framing effect, the effects of psychological constructs on individuals' preferences matched several of our assumptions. Individuals with a high Consideration of Future Consequences have an increased preference for the sanitary measure, whereas those with high Environmental self-identity opt for the transportation choice with reduced emissions. Lastly, we analyzed the heterogeneity in the loss framing effect according to individuals' motivational strategies. It was revealed that individuals with a low Promotion score were strongly affected by loss framing on CO₂ emissions, meaning that the magnitude of framing depends on individuals' motivational strategies.

The present research is original in the field of transportation behavior by virtue of being the first study to analyze the persuasiveness of attribute valence framing in trip choice. In most cases, the theoretical paradigm guiding public transit policies stems from the normative approach to decision-making (Von Neumann and Morgenstern, 1947). Departing from this approach, the framing effect (Tversky and Kahneman, 1981) suggests that small changes in the presentation of an optional choice can produce somewhat surprisingly large changes in subsequent behavior.

Our results have several potential public policy implications. First, it would be worthwhile for public transit operators to apply loss framing on the CO₂ attribute. For instance, railway companies could use this type of framing to positively promote train travel, in comparing it with other more CO₂-intensive trip modes. In France, the online booking website of the French national railway company (SNCF) automatically displays CO₂ information before ticket purchase. According to this site, the quantity of CO₂ per traveler depends on both the number of kilometers and type of train. A very fast train (called TGV) produces about 2 grams per passenger-kilometer, while a slower train (called TER) produces some 25 grams. In many cases, users have the choice between a fast train, a slower train or a combination of both. The use of loss framing could encourage individuals to choose an itinerary that limits CO₂ emissions. This type of measure could be generalized to the CO₂ emissions for all transportation communication and advertising. For airline companies, CO₂ emissions can also differ greatly since emissions are sensitive not only to the type of aircraft and

travel distance but also to other criteria, like the number of layovers. Once again, loss framing for CO₂ might also encourage users to opt for greener trips.

Our work has raised some issues that require further investigation. First, the fact that framing effects depend on individuals' motivational strategies is a powerful result that should be further analyzed and validated with respect to psychological theory. More generally, future research should focus on finding and including new psychological constructs capable of improving our understanding of individuals' behavior in the field of transportation. Such an advance would lead to a better understanding of traveler choices, which could serve to design appropriate pro-environmental policies. Second, we showed that the effect of loss framing was greater for CO₂ than for duration. One possible explanation for this finding is that framing on a more distant or complex attribute (e.g. kg of CO₂ emissions) has a greater effect than a framing on an already well-known and typical attribute (e.g. duration). This difference should be investigated in order to ascertain whether it is caused by the fact that CO₂ emissions is an abstract indicator. If so, it would be beneficial to find a way to communicate on CO₂ emissions with a more understandable unit of measurement. Adding such kind of framing to the attribute's loss framing we presented in this article is not trivial. This issue needs to be carefully addressed in future works to investigate how the combination of different types of framing may affect individuals' decisions.

References

- Andersson, A. (2020). Is climate morality the answer? preconditions affecting the motivation to decrease private car use. *Transportation Research Part D: Transport and Environment*, 78:102198.
- Arbuthnott, K. D. and Scerbe, A. (2016). Goal framing in public issue and action decisions. *Analyses of Social Issues and Public Policy*, 16(1):175–192.
- Avineri, E. (2012). On the use and potential of behavioural economics from the perspective of transport and climate change. *Journal of Transport Geography*, 24:512–521.
- Avineri, E. and Waygood, E. O. D. (2013). Applying valence framing to enhance the effect of information on transport-related carbon dioxide emissions. *Transportation research part A: policy and practice*, 48:31–38.
- Bouscasse, H., Joly, I., and Bonnel, P. (2018). How does environmental concern influence mode choice habits? a mediation analysis. *Transportation research part D: transport and environment*, 59:205–222.
- Crabbe, M. and Vandebroek, M. (2012). Using appropriate prior information to eliminate choice sets with a dominant alternative from D-efficient designs. *Journal of Choice Modelling*, 5(1):22–45.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3):297–334.
- Davison, L., Littleford, C., and Ryley, T. (2014). Air travel attitudes and behaviours: The development of environment-based segments. *Journal of Air Transport Management*, 36:13–22.
- Demarque, C., Apostolidis, T., Chagnard, A., and Dany, L. (2010). Adaptation et validation française de l'échelle de perspective temporelle "Consideration of future consequences" (CFC). *Bulletin de Psychologie*, 5:351–360.

- Giansoldati, M., Rotaris, L., Scorrano, M., and Danielis, R. (2020). Does electric car knowledge influence car choice? Evidence from a hybrid choice model. *Research in Transportation Economics*, 80:100826.
- Haws, K. L., Dholakia, U. M., and Bearden, W. O. (2010). An assessment of chronic regulatory focus measures. *Journal of Marketing Research*, 47:967–982.
- Hensher, D. A. and Greene, W. H. (2003). The Mixed Logit model: The state of practice. *Transportation*, 30:133—176.
- Higgins, E. (1997). Beyond pleasure and pain. *The American psychologist*, 52(12):1280–300.
- Hilton, D., Charalambides, L., Demarque, C., Waroquier, L., and Raux, C. (2014). A tax can nudge: The impact of an environmentally motivated bonus/malus fiscal system on transport preferences. *Journal of Economic Psychology*, 42:17–27.
- Homar, A. R. and Cvelbar, L. K. (2021). The effects of framing on environmental decisions: A systematic literature review. *Ecological Economics*, 183:106950.
- Hoyle, R. (2012). *Handbook of Structural Equation Modeling*. Guilford Press.
- IEA (2018). Co2 emissions from fuel combustion 2018. Technical report.
- Joireman, J. A., Van Lange, P. A., and Van Vugt, M. (2004). Who cares about the environmental impact of cars? those with an eye toward the future. *Environment and behavior*, 36(2):187–206.
- Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decisions under risk. *Econometrica*, 47(2):263–292.
- Lancaster, K. J. (1966). A new approach to consumer theory. *The Journal of Political Economy*, 74(2):132–157.
- Levin, I. P., Schneider, S. L., and Gaeth, G. J. (1998). All Frames Are Not Created Equal: A Typology and Critical Analysis of Framing Effects. *Organizational Behavior and Human Decision Processes*, 76(2):149–188.
- Louviere, J. J., Hensher, D. A., and Swait, J. D. (2000). *Stated Choice Methods, Analysis and Applications*. Cambridge University Press.
- Mabit, S., Caussade, S., and Hess, S. (2006). Representation of taste heterogeneity in willingness to pay indicators using parameterization in willingness to pay space. *Proceedings ETC*.
- McFadden, D. (1974). Conditional logit analysis of qualitative choice behaviour. In *Frontiers of econometrics*. Academic Press, New York.
- McFadden, D. and Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics*, pages 447–470.
- Mir, H. M., Behrang, K., Isaai, M. T., and Nejat, P. (2016). The impact of outcome framing and psychological distance of air pollution consequences on transportation mode choice. *Transportation Research Part D: Transport and Environment*, 46:328–338.

- Moon, S., Bergey, P. K., Bove, L. L., and Robinson, S. (2016). Message framing and individual traits in adopting innovative, sustainable products (isps): Evidence from biofuel adoption. *Journal of Business Research*, 69(9):3553–3560.
- Morton, T. A., Rabinovich, A., Marshall, D., and Bretschneider, P. (2011). The future that may (or may not) come: How framing changes responses to uncertainty in climate change communications. *Global Environmental Change*, 21(1):103–109.
- Offiaeli, K. and Yaman, F. (2021). Social norms as a cost-effective measure of managing transport demand: Evidence from an experiment on the london underground. *Transportation Research Part A: Policy and Practice*, 145:63–80.
- Raux, C., Chevalier, A., Bougna, E., and Hilton, D. (2020). Mobility choices and climate change: Assessing the effects of social norms, emissions information and economic incentives. *Research in Transportation Economics*, page 101007.
- Rose, J. M. and Masiero, L. (2010). A comparison of the impacts of aspects of prospect theory on wtp/wta estimated in preference and wtp/wta space. *European Journal of Transport and Infrastructure Research*, 10(4).
- Scarpa, R., Thiene, M., and Train, K. (2008). Utility in willingness to pay space: a tool to address confounding random scale effects in destination choice to the alps. *American Journal of Agricultural Economics*, 90(4):994–1010.
- Stiglitz, J. E. (2019). Addressing climate change through price and non-price interventions. *European Economic Review*, 119:594–612.
- Strathman, A., Gleicher, F., Boninger, D. S., and Edwards, C. S. (1994). The Consideration of Future Consequences: Weighing Immediate and Distant Outcomes of Behavior. *Journal of Personality and Environmental Psychology*, 66(4):11.
- Strathman, A. and Joireman, J. (2006). *Understanding behavior in the context of time: Theory, research, and application*. Psychology Press.
- Thaler, R. H. and Sunstein, C. R. (2008). Nudge: improving decisions about health. *Wealth, and Happiness*, 6:14–38.
- Train, K. (2009). *Discrete Choice Methods with Simulation*. Cambridge University Press, 2nd ed. edition.
- Train, K. and Weeks, M. (2005). Discrete choice models in preference space and willingness-to-pay space. In *Applications of simulation methods in environmental and resource economics*, pages 1–16. Springer.
- Tversky, A. and Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481):453–458.
- Tversky, A. and Kahneman, D. (1991). Loss Aversion in Riskless Choice: A Reference-Dependent Model. *The Quarterly Journal of Economics*, 106(4):1039–1061.

- Van der Werff, E., Steg, L., and Keizer, K. (2013). It is a moral issue: The relationship between environmental self-identity, obligation-based intrinsic motivation and pro-environmental behaviour. *Global Environmental Change*, 23(5):1258–1265.
- Van Lange, P. A. and Joireman, J. A. (2008). How we can promote behavior that serves all of us in the future. *Social Issues and Policy Review*, 2(1):127–157.
- Von Neumann, J. and Morgenstern, O. (1947). *Theory of games and economic behavior*. Princeton University Press, 2nd ed. edition.
- Waygood, E. O. D. and Avineri, E. (2018). CO₂ valence framing: Is it really any different from just giving the amounts? *Transportation Research Part D: Transport and Environment*, 63:718–732.