THE EFFECT OF LOSS FRAMING ON THE PERCEIVED DIFFERENCE OF CO2 AMOUNTS: IMPLICATIONS FOR ADVANCED TRAVEL INFORMATION SYSTEMS (ATIS)

Dr E. Owen Waygood*

Research Associate

Dr Erel Avineri†

Reader

Centre for Transport & Society

Faculty of Environment and Technology

University of the West of England

Coldharbour Lane, Bristol

UK BS16 1QY

*Tel. 0117.328.6435

*owen.waygood@uwe.ac.uk

†Tel. 0117.328.3197

†erel.avineri@uwe.ac.uk

ABSTRACT

The provision of information on carbon dioxide (CO_2) generated by transport to the traveller can be seen as an instrument to increase the likelihood of more sustainable choices being made by individuals. However, little attention has been paid to the design of such information. Loss framing is one technique that could potentially highlight desirable choices, and affect motivation, intention and travel choice behaviour, but its application has not been studied in the context of CO_2 information. Loss framing refers to semantically restructuring (framing) a choice so that the tendency for people to avoid losses (loss aversion) guides them to a particular choice. Although loss framing has been found effective in fields like health and home energy use, those considerations had personal impact and dealt with familiar information. Unfortunately, CO_2 is a relatively new concept which most people likely don't have experience with and the effects of climate change have external costs rather than personal 'loss' and therefore sustainable mobility choices could be seen as a social dilemma. Therefore, it is not clear whether loss framing would be affective in altering an individual's perceptions. In order to test that, a survey was developed to examine the effect of loss framing on perceived differences between travel-related CO_2 amounts. The findings imply that loss framing could be used to highlight differences in CO_2 amounts and thus influence decisions through the design of travel-related choices. Advanced Traveller Information Systems (ATIS) designers would structure the presentation of information so that the less (socially) desirable choices had their increased CO_2 (the loss) highlighted.

1. INTRODUCTION

Providing individuals with information about transport-related attributes such as travel time, travel costs or risks might be seen not only as a service provided to the public, but as an instrument to change travel behaviour. The presumption is that informed travellers will make 'better' choices which will be to their personal advantage and potentially that of the transport system as a whole. The provision of information to the traveller on carbon dioxide (CO_2) and other greenhouse gases (GHG) emissions generated by transport can be seen as an instrument to increase the likelihood of more sustainable choices being made the individual. While we don't know the effect of such information, it is widely accepted that without providing information on CO_2, it is less likely that individuals will make climate-friendly choices.

Recently there has been increasing interest in the influence of psychological and social aspects on travellers' behaviour. The so-called 'softer' side of transport policy was implemented in the UK under the name 'Smarter Choices' (see, e.g., Cairns et al, 2004). Somewhat inspired by social psychology, it is a wide range of rather diverse measures including persuasive and information elements.

A different approach to behaviour change is the one suggested by Thaler & Sunstein (2008) and other behavioural economists. Through 'choice architecture', and the incorporation of the so-called 'nudges' into the choice environment, policy makers can devise interventions that help people make better decisions (Avineri, 2011). They may also be less controversial and cheaper than larger scale interventions of the sort discussed above (Avineri and Goodwin, 2010).

Although there is potential for information to lead to such choices, more consideration to how it is presented - the design of information context rather than information content- could better highlight sustainable choices. One design consideration is the semantic presentation of information. Simply changing the way information is presented, or framed, has been shown to affect perception and choice in other fields such as finance, health, and home energy use (Thaler and Sunstein, 2008). For example, people tend to feel and behave differently when information is presented (or 'framed') in terms of gains or losses (Kahneman and Tversky, 1979).

The framing effects studied in the literature deal with information that is directly relevant and familiar to the individual; however for most people the effects of climate change will have external cost rather than personal cost and therefore sustainable mobility choices could be seen as a social dilemma, in which the individual is not aware of the external costs, or not motivated enough to reduce them. Moreover, for many people CO_2 information is an unfamiliar consideration, with very little direct experience with it measurement and effect, so it is not obvious that the techniques successfully applied in other fields will be effective in a climate change context. However, there is potential that effective framing techniques could affect perceptions of CO_2 emissions as well.

In this article we examine whether the design consideration of gain/loss framing could increase the perception of differences about the mass of travel-related CO_2 emissions. Survey participants' responses to word framing that highlighted differences between travel options in either a positive or negative view were compared using an ordered logit model. Through qualitative analysis of participants' responses in a focus group we have gained some in-depth understanding of individuals' responses to gain/loss framing of travel-related CO_2 emissions.

2. BACKGROUND

Based on the assumption that better informed people will make more sustainable choices, CO_2 information is being used to influence choice. In some cases, the CO_2 alone is being presented, while in other situations it has financial impacts. A range of web-based tools provide transport-related CO_2 information to individual travellers; these include carbon calculators and journey planners. CO_2 information is also provided to participants of travel programs such as Travel Blending in Australia (Rose and Ampt, 2001) and Travel Feedback

Program in Japan (Taniguchi et al, 2003). Some carbon calculators offer users carbon offsetting and in the UK, tax bands are associated to estimates of CO_2 outputs on a grams per kilometre basis.

Recently, the assumption that CO_2 information can affect travel choices has been examined through choice experiments. Without directly translating CO_2 outputs into a financial consideration, Gaker et al (2010) have conducted experiments on route-choice and automobile purchase. Their conclusion was that information on GHGs like CO_2 could affect choice.

The theory of rational choice assumes that preferences are not affected by how the information is presented, as long as the amounts are available; that no matter the framing, the individual will always have the same interpretation of the information. However, research on how information is presented, or framed, suggests that highlighting differences can increase the perception of those differences and affect choice. *Framing* is the semantic manipulation of rationally identical problems. In *semantic framing* only alternative phrasing is used, while in *valence framing*, information is put in either a positive or negative light (Hallahan, 1999). Semantic framing may reorganize a sentence so that a key point comes at the beginning rather than the end. Valence framing attempts to put something in a positive or negative light (e.g. the spin on a story) such as renaming "tax cuts" as "tax relief" because "relief" has positive connotations. In a transport decision process, a project may be described as "reducing CO_2 emissions by 10%" which highlights the positive impact of the project in relation to the current situation.

Related to valence framing and semantic framing is a framing technique that highlights losses called *loss framing*. Loss framing semantically changes the presentation of choices so that the negative impact, or loss, is highlighted. For example, rather than saying, "chocolate bar A costs 50p and chocolate bar B costs 40p", loss framing would read, "chocolate bar B is 40p and chocolate bar A is 10p *more*." The information is the same, but how it is semantically organized has changed so that the loss, "10p more", is clear. This is contrast to the example above where the framing highlighted the positive change that the transport project would have (gain framing). The reason for highlighting the loss rather than the gain is that people tend to avoid losses more than they seek gains.

The tendency to avoid losses is called *loss aversion* (Kahneman and Tversky, 1979). Kahneman and Tversky (1979) showed that individual choices are more affected by potential losses than equal gains, defined and measured against some reference point. Recent studies provide evidence that travellers exhibit aversion to loss and have a strong tendency to avoid choices associated with losses (Avineri and Prashker, 2004, Avineri and Prashker, 2003, van de Kaa, 2010). Avineri (2006) demonstrated how a change in the perceived value of the reference point in a route-choice problem could lead to improved traffic equilibrium.

Studies from the health field (Kühberger, 1998) and home energy use (Gonzales et al, 1988) have found that framing affects choice. In the health field a meta-analysis of 136 empirical papers found that framing is a reliable phenomenon (Kühberger, 1998). However, both those fields deal with losses to the individual and with relatively familiar topics such as financial loss or negative health impacts. The theory of rational choice would suggest that an individual will try to maximize the benefits or value for them self. In opposition to that, Tversky and Kahneman (1981) have found that loss framing also works for choice that does not directly impact the decision maker, such as the loss of others' lives.

As a result of loss framing's success in influencing choices in other fields, the need for an investigation on CO_2 emissions mass may seem limited. However, the previous examples did not consider social dilemmas such as climate change, and the nature of impacts is different. In the context of transport, the problem of climate change may be considered a social dilemma as people might feel that their personal mobility is being restricted, while the benefits are to society. Tversky and Kahneman's (1981) work considered a fictional "Asian disease" where choice would affect many others; however it was not presented as a social dilemma. A disease is not the result of an individual's action (though the spread of it may be enhanced by certain individual behaviour), whereas actions that increase CO_2 amounts in the atmosphere (a global commons) contribute to climate change which may affect many others. Considerations of personal health or finance have a direct impact on the individual so the desire to avoid risk may be greater than if one's actions do not have that direct personal

impact. As well, all of those considerations deal with familiar concerns, whereas CO_2 is a relatively new issue and people have difficulty interpreting it (Coulter et al, 2007, Waygood and Avineri, 2010).

Further to those points is that loss aversion's effect varies depending on the type of loss. Tversky and Kahneman (Tversky and Kahneman, 1991) summarized findings that the coefficient of loss framing (the effects of gain framing over loss framing) was greatest for safety, followed by money, and then leisure. They write, "the coefficient... reflects the importance or prominence of the dimension". The importance of CO_2 information to individuals is not clear, and thus the effectiveness of loss framing in that context is not known.

To summarize, the evidence on CO_2 information being presented to individuals suggest that it does affect decisions, but the magnitude of its impact could potentially be increased through choice architecture tools such as loss framing. However, there are a number of differences between CO_2 information and previous applications of loss framing that may affect its effectiveness such as familiarity and indirect impact. Therefore, research that examines whether loss framing could better emphasize the difference between the amounts of CO_2 produced by a choice set would help designers of information build more effective communication tools.

3. METHOD AND DESCRIPTIVE RESULTS

To increase the likelihood of more sustainable choices being made, techniques such as loss framing may work. The question of whether loss framing is effective with CO_2 information despite it being a relatively unfamiliar concept and does not seem as personal a cost to the traveller is examined in this paper. This section will introduce the survey questions, the participants, and then end with descriptive results. In the following sections we present the statistical analysis of the survey responses, and the summary of findings from the focus group conducted to gain in-depth understanding of public's responses to gain/loss framing.

To test the effectiveness of gain and loss framing, two comparison sets were semantically restructured so that gains and losses were distinctly presented. From the background literature (Avineri and Goodwin, 2010, Kahneman and Tversky, 1979, Gonzales et al, 1988, Tversky and Kahneman, 1981, Edwards et al, 2001) we know that loss framing is generally more effective than gain framing at influencing choice so, the anticipated result is that loss framing will have a greater impact. In order to eliminate the impact of other considerations on choice (such as comfort, cost, etc.) this experiment only considers the perception of the difference between two CO_2 amounts. Thus, we hypothesize that *loss framing will result in a greater perceived difference between the CO_2 amounts*.

The comparison sets were based on the per passenger amounts of CO_2 produced over a five mile trip by a bicycle, full car, and single occupancy 4x4 (or sports utility vehicle). The amounts were 132g, 500g, and 3400g respectively and were calculated using www.travelfootprint.org. The resulting comparison sets were 132g versus 500g, and 500g versus 3400g.

After semantically reorganizing the comparison sets, the resulting four sentences are shown in Figure 1.

Those four sentences were divided so that each participant answered one with gain framing and one with loss framing, but not of the same comparison set (e.g. *i* and *iii*, *ii* and *iv*). To avoid associations of sustainability with actual modes, mode names were excluded so that for each comparison, the participants were asked, "Compared to mode X, mode Y is." The response choices were on an ordinal scale of "about the same," "slightly different," or "much different."

There were 194 adult participants who ranged in age from 19 to 76 (average 39) years old, 48.4% were female, and 57.5% had higher education. The questions were part of a larger survey that was administered through the Carbon Aware Travel CHoices (CATCH) project[1].

i. Loss framing for comparison set 1:
Mode X produces 132g of CO_2 for a 5 mile trip.
The amount produced by mode Y is 368g higher (i.e. worse).

ii. Gain framing for comparison set 1:
Mode X produces 500g of CO_2 for a 5 mile trip.
The amount produced by mode Y is 368g lower (i.e. better).

iii. Loss framing for comparison set 2:
Mode X produces 500g of CO_2 for a 5 mile trip.
The amount produced by mode Y is 2900g higher (i.e. worse).

iv. Gain framing for comparison set 2:
Mode X produces 3400g of CO_2 for a 5 mile trip.
The amount produced by mode Y is 2900g lower (i.e. better).

FIGURE 1: The gain and loss framing for two CO_2 emissions comparison sets.

The descriptive results to the four questions are shown in Figure 2. There are several observations that can be made from this figure. First, for both comparison sets, there is an apparent increase in the number of participants selecting "much different," suggesting that loss framing can accentuate the perceived difference between CO_2 amounts. Second, the gain framing results are extremely similar despite different people completing the questions and comparison sets with different magnitudes of CO_2 being compared. Third, the effect of loss framing is more pronounced in the second comparison set with larger amounts being compared. Those last two observations suggest that the effect of scale, or magnitude, should be considered in the statistical analysis.

4. ANALYSIS

The descriptive results suggest that there are impacts from both loss framing and the scale of the CO_2 being compared on how people perceived difference. In order to test whether these differences were statistically significant, an ordered logit (OL) model was used with the dependent variable being the response on perceived difference. OL models are used to examine ordinal scale dependent variables such as "high, medium, low" and are appropriate for this type of analysis (see e.g.,Ben-Elia and Ettema 2009) for a more detailed description of OL models). The models were estimated with the BIOGEME software version 1.6 (Bierlaire, 2008). To allow for analysis, the responses were coded as:

- "About the same" = 0,
- "Slightly different" = 1,
- "Much different" = 2.

[1] www.carbonaware.eu

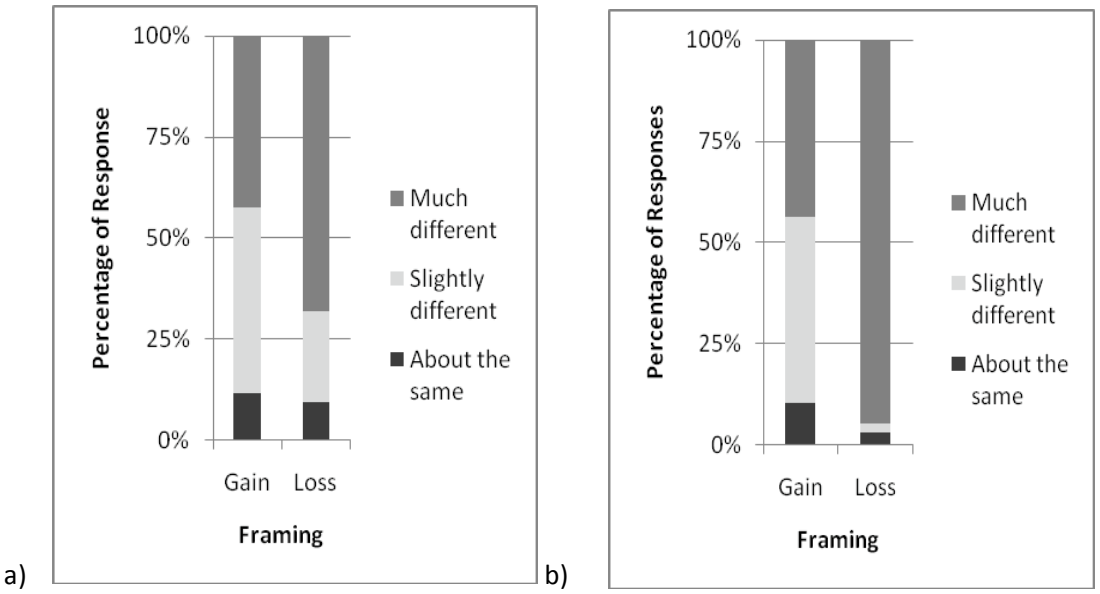

FIGURE 2 Generalized response to gain (ii,iv) and loss (i,iii) framing. a) 132 g and 500g example (i, ii), b) 500g and 3400g example (iii, iv).

Although the primary focus of this paper is the effect of loss framing, to check for any impact of age, gender, or education, those variables were also included in an initial model, but as they were found to be highly insignificant, were removed from the final model presented here. From the descriptive results, the scale of the comparison ('small' CO_2 outputs presented as set 1, or 'large' CO2 outputs presented at set 2, see Figure 1) appeared to be relevant, so a dummy variable was included. The final model results are shown in Table 1.

TABLE 1 Results of the OL estimation for perception of difference.

Coefficient definition	Value	Std err	*t*-Test	*p*-Value
Loss framing is true	1.59	0.229	6.97	<0.001
Large CO_2 emissions (choice set 2) is true	0.62	0.217	2.84	<0.001
Threshold 1 from "About the same" to "Slightly different"	-1.35	0.206	-6.53	<0.001
Threshold 2 from "Slightly" to "Much different"	0.538	0.179	3	<0.001
Number of estimated parameters	4			
Number of observations	388			
Null log-likelihood	-426.3			
Final log-likelihood	-316.5			
Likelihood ratio test	219.5			
ρ^2	0.258			
Adjusted ρ2	0.248			

The relevant interpretations of the model are that both loss framing and scale explained a significant amount of the variation, and that loss framing had the larger overall effect. The

parameters were both positive, confirming the interpretation of the descriptive results, that loss framing and larger values increase the likelihood of the perceived difference being "much different." Using the adjusted rho squared, the model explained nearly 25% of variation.

Odds ratios can be used to determine the likelihood of "much different" being selected in comparison with either "about the same" or "slightly better." For the comparison between 132g and 500g, the odds ratio that the difference will be interpreted as "much" for loss framing versus gain framing is 2.84 (Fisher's exact test $p < 0.001$). For the comparison between 500g and 3400g, the odds ratio that the difference will be interpreted as "much" is 22.89 (Fisher's exact test $p < 0.001$). Considering that, it is likely that the scale of the emission figures has a significant effect on the interpretation of the difference. This result will be further discussed in the Discussion section.

4.1. Findings from a Focus Group

As the potential application of loss framing would be for governments to highlight more societally desirable choices, and being as transparent as possible, citizens would likely become aware of its use. It would therefore be of interest to public sector practitioners what the public's opinion on its application would be. With respect to that concern, the technique and the results of the study were discussed in a focus group.

Although the technique of loss framing was found to be an effective means of increasing the perception of difference between two CO_2 amounts, the acceptability of its application with the public is not clear. It could be argued that the technique presents the same information and is simply more effective at highlighting the difference. However, people might interpret that as manipulation, which is likely not acceptable, or at least not desirable. To investigate this assumption, the technique and the results of this experiment were discussed with a group of individuals who had completed the survey described in section 3.

Six individuals participated in the focus group held in Bristol, UK: three men and three women; with and without higher education; and in the age range of 23 to 65 years old. Before showing the survey results or mentioning "loss framing", the concept of *framing* was first introduced and an example using money was given to help improve understanding. The example given was:

- If you buy this ticket you'll have the chance to win £100.
- If you don't buy this ticket, you'll miss the chance of winning £100.

The participants were asked which they felt would work better to motivate purchase of the ticket. Four out of the six felt that the positive framing would work better. People commented that (they believed) positive associations or benefits would be a stronger motivator. This suggests that people think they are more influenced by positive framing.

The concept of loss aversion was then verbally introduced and the different examples used in the survey were shown (see section 3). Following that, the results of the above analysis were shown where the loss framing resulted in more people feeling that the difference was large. The participants were allowed some time to digest the results and allowed to ask questions to clarify.

The participants were then told that governments might use this technique to highlight more sustainable choices. They were then asked if they felt it was appropriate for government to do so.

The general response was that it felt like manipulation and that government institutes shouldn't apply such techniques and that information from the government should be straight forward. The focus group facilitator then commented that such techniques were used by companies to improve sales, and asked how they felt about that. The general feeling was

that it was fine for private businesses to use it, but not for government. One woman (aged 26) commented that, "I'll take advertising with a grain of salt, but I feel like the government should be clear."

The facilitator further highlighted that information is often framed, such as stating that a certain project will reduce time expenditures. The information does not say time will change from 30 minutes to 29 minutes. The participants were asked to consider that such framing was common, but perhaps applied without consideration to its impacts. With that in mind, would it be better to consciously highlight a more desirable choice for society? The response by the participants was still that information shouldn't be manipulated.

Although not directly related to gain/loss framing, one further question was asked to the individuals that related influencing choice through information design. In the UK it is frequently possible to see an information provision on the healthiness of food that uses a "traffic-light" system (http://www.eatwell.gov.uk/foodlabels/trafficlights/). The system works where red means a high amount of an ingredient that should be limited (restrict consumption of such products), amber means that it is neither high nor low (it's okay to consume more regularly), and green means low (the more green, the healthier the choice). Although these are judgements made by a government institution, the participants felt that such information design was acceptable and in some instances desirable. The participants commented that if they wanted to check the information, it was there and that the judgement was desirable as they did know what appropriate amounts/levels were.

The general feeling was that manipulations should be left to commercial companies, but that providing information with expert judgements would allow people to then decide if they wanted to pay attention or not. Therefore, with consideration to public acceptability, a system similar to the food traffic light one where an expert judgement on whether the amount of CO_2 was good or bad for a specific use or situation was given would be more desirable than the technique of loss framing to influence choices.

5. DISCUSSION

This research found that for CO_2 emission amounts, loss framing was an effective means of increasing the perceived difference as compared with gain framing. Although the CO_2 amounts do not have a direct private cost, the technique was still found to affect interpretation.

Assuming that if the perception of the difference is larger for loss framing, and if CO_2 was included in the decision making process, there would be an increased likelihood of the lower CO_2 emissions choice being made by the individual. The two caveats of consideration and choice point to future research: would CO_2 information be considered by the general public if provided; would loss framing increase the *choice* of more climate-friendly transport options? Gaker et al.'s (2010) work found that the first is true for university students and that it affected choice, but this has not been examined for a more representative sample and might vary from population to population depending on overall environmental awareness.

The results of the focus group though would suggest that to improve carbon-friendly choices, a judgement system would be preferential to loss framing if applied by the government. If, however, the designers of information are not a government institute, but a business (or community representatives), there seems to be greater acceptance of "manipulative" techniques such as loss framing.

Loss framing was statistically better than gain framing at highlighting the difference between two CO_2 amounts. This suggests that information systems such as Advanced Traveller Information Systems (ATIS) could highlight more desirable choices by displaying the negative impact of choosing the less desirable mode choice.

Further, Chorus et al. (2006) in a review of the use of information in transport, suggest that post-trip information may be more effective in changing travel behaviour. Based on those two points, an example might be "You produced 2000g more of CO_2 than if you'd used public transit for this trip."

Loss framing was accentuated by an increase in scale which suggests that larger comparisons may be more effective at increasing the perceived difference than smaller ones. As the mode choices will limit what could be shown on a trip-by-trip basis, potentially accumulated amounts like yearly outputs could be more effective. This might be an important question for future studies.

Research from home energy efficiency suggests that summing small losses has a greater effect than highlighting each individual loss (Gonzales et al, 1988). Avineri (2011), following Thaler (1985), illustrated how the combination and segregation of travel choice attributes, framed as gains and losses, might increase the attractiveness of some choices. A future research question might then be, would an accumulative difference be more likely to lead to a change? For example, should a driver be presented with information highlighting how much CO_2 is being produced per trip or yearly in comparison to alternative choices?

The different impacts of the loss framing due to the scale were not anticipated, but several interpretations are suggested here. The first is that the ratio between the two amounts within each comparison set is different with the first being 1:3.8 and the other 1:6.8. However, the odds ratio is nearly ten times larger. The second is the absolute difference between the amounts with the first comparison set differing by 368g, whereas the second differs by 2900g. Here, the amounts nearly differ by a scale of 1:8 which is closer to the difference seen. The third is the actual number. Would the interpretation have varied if kilograms were used rather than grams? Loss framing would still likely have an effect, but the magnitude of that effect may vary depending on if the differences were expressed as 0.37kg and 2.9kg rather than 368g and 2900g. In that situation, perhaps the first comparison set would not have seemed different. These questions fit well with those suggested above and further insights can be gained by future research.

6. CONCLUSION

CO_2 information is being introduced to affect transport choices, but further design considerations could increase its potential. CO_2 information is not familiar and is a social dilemma as opposed to a personal one. Despite those differences, for two comparison sets, the effect of loss framing was found to be significant, though the magnitude of the effect was much larger for the 500g and 3400g set compared to the 132g and 500g set.

This suggests that loss framing could be successfully applied to situations where CO_2 information is being presented to better highlight desirable choices. This includes transport related tools like Advanced Traveller Information Systems or CO_2 tax bands on cars. Future research should apply these findings in choice set experiments that relate to transport situations like mode choice or car purchase.

A second finding was that the size of the CO_2 amounts affects perceived differences. Considering that result, future experiments should examine whether trip-by-trip comparisons are less effective than combined amounts (such as weekly or yearly) at affecting perception and choice.

Lastly, qualitative results suggest that members of the public might have concerns about the use of loss framing by governments which are generally not favoured by the public, but that expert judgements of high or low amounts would be more acceptable.

To conclude, the findings suggest that loss framing might help to improve the design of information-based initiatives as it works as a ‘nudge’ to improve the effect of information on CO_2 and is therefore likely to increase the choice of sustainable options. The potential application of loss framing would be for governments (and other travel information providers) to highlight and ‘nudge’ more sustainable travel choices, and being as transparent as possible. This approach could be applied in the ‘choice architecture’ of ATIS (such as web-based journey planners, navigation and way-finding devices, and in-vehicle information systems) or as part of other behaviour change measures (such as personal travel planning).

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