

Visual Formats, Reference Points, and Anchoring Effects on Perceptions of the Sustainability of Travel Choices

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Abstract—To reduce the amount of carbon dioxide (CO₂) produced by transport, a shift in travel behavior to more carbon friendly choices is necessary. Choice theory traditionally suggests that decision makers base choices on the attributes of their choice set. However, how the information on those attributes is presented could affect perceptions of the attributes and the alternatives. This paper examines how the presentation of CO₂ information can affect the perception of sustainability with consideration to: visual or text formats; reference points; and anchoring effects.

I. INTRODUCTION

PROVIDING relevant transport information is a service that can affect choice. Global concerns over green house gases which include carbon dioxide (CO₂) [1] have resulted in related information being provided to individuals. Some carbon calculators and journey planners provide such information on the level of CO₂ generated by the user. However, despite the serious nature of the problem little research has examined the effect of presentation format on the user's response to the information, and how CO₂ information should be best presented. This paper will consider how the presentation of CO₂ information affects perception. The two main effects considered are reference point and anchoring; these have been mainly explored in behavioral sciences and their application to the design of travel information systems is illustrated and discussed through an empirical study.

II. BACKGROUND

Concerns over climate change, air pollution, and sustainable transport are leading governments to take actions to change the way people travel. Information on travel choices could be seen not only as service to the users, but also as a 'soft' measure to influence their choices.

The theory of choice, as described by Ben-Akiva and Lerman [2], suggests that there are four crucial elements of choice making: the decision maker, the alternatives, the attributes of the alternatives, and the decision rule. Through

the provision of information on the set of choices and their attitudes, the decision maker could evaluate and compare the attractiveness of the choices, represented by some "utility" to her.

However, information could be provided not only on the alternatives' attributes but also on other aspects of the decision-making problem. Information on the environmental costs of transport choices might help in changing one's knowledge of, attitudes towards or perceived values of transportation choices. In this paper we argue that the context in which alternatives are presented can affect perception, one part of the decision rule process (Fig. 1).

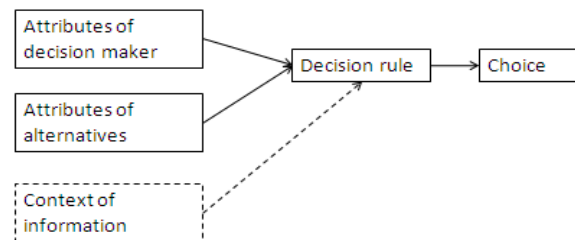


Fig. 1. Theory of choice based on Ben-Akiva and Lerman [2] (solid lines) with proposed influence from the context of information proposed in this paper (dashed lines).

CATCH (Carbon Aware Travel CHOice) is an ongoing EC project that aims to develop and disseminate an open-knowledge platform for information and advice on reducing transport-based CO₂ [3]. With consideration to that, how choices are made must be considered.

A recent review of journey planners and carbon calculators [3] reported that CO₂ information is always presented as weight, though some use equivalents (e.g. trees, number of "Earths" required if all people behaved likewise), and a few show comparisons to averages (e.g. regional, national, socio-demographics). These presentation styles are all likely to have different results on how the information is perceived by the user. How weight is being perceived likely depends on background knowledge or some contextual information being given to the user. The equivalents try to concretize the information, with the earth format potentially giving greater contextual information.

How an individual assesses the outcome of a choice is often determined in large part by its contrast with a 'reference point' [4]. It has been observed that attributes of choices are reference-dependent and are commonly evaluated as 'gains' and 'losses', where losses have a much larger psychological effect on choice preferences than gains

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[4,5].

Another important concept related to information provision is the use of a 'budget'. For attributes such as time and money, people will commonly have some (perceived or real) budget that provides context and could be seen as a reference point that determines whether the amount required is acceptable or not. However, due to low knowledge on CO₂ information people may not naturally have a budget to provide either context or a reference point by which to make a judgment. Therefore, providing information on a CO₂ 'budget' might have an effect on users.

Another concept that was studied is the use of *anchoring effect*. An anchor is additional information not directly being judged. Anchors could be used to affect how large or small a number is perceived to be. When people have low prior knowledge, the effect of additional information (anchoring effect) will have an increased impact on estimates [6], even if that information is known to be random [7].

One study with groups of users and non-users of carbon calculator websites found that providing CO₂ information as weight had little meaning for both groups [8], suggesting that people lack sufficient prior knowledge to make judgments. That implies that anchors will likely have a large effect on judgments made about CO₂ information. Presentation styles that give context to the judgment may decrease the anchoring effect.

Providing comparisons to the level of CO₂ among other users may act as reference points, perhaps suggesting that using more energy than average is a loss and that using less is a gain. It may also have a *social norm effect*: people will tend to behave as others. A study that examined the impact of giving averages on household energy use [9] found a tendency to move towards the average for *both* low use and high use households. The tendency of the "good" (low energy use) performers to increase consumption was cancelled out by giving a judgment feedback (in this case a smiley face). Therefore, social norm information can have a positive effect on "poor" performers, but provision should be made for "good" performers. This effect is not examined in this study, but is mentioned in response to how CO₂ information is currently being presented.

Considering that people appear to have low prior knowledge on CO₂, the use of equivalents can have positive effects on comprehension. People have different learning styles [10] with some people preferring visual images rather than verbal (with text being a representation of verbal). The use of images can have other benefits by concretizing abstract concepts [11] and has been found to help individuals with low prior knowledge [12].

Another consideration is whether the information is relevant to the audience. Research on stages-of-change [13] suggests that certain information will only be relevant to people at a particular stage-of-change. This means that people may need to be aware that climate change is a problem and that CO₂ has an effect on it before they would consider CO₂ information related to choices.

To increase relevancy to people, governments are contemplating cap and trade or carbon tax systems. Cap and trade systems could change behavior by acting as the reference point and through market mechanisms. The tax system would likely only act through market mechanisms. One study that compared how people reacted to the two schemes, found that individuals preferred the cap and trade system (in this case a tradable carbon permit) as it gave them a point of reference [14]. That suggests that giving a reference point that allows judgments may be more acceptable (and potentially create more positive change) than moving CO₂ considerations into a financial context.

From the above, there are a few key issues that should be considered. One is the presentation style, or format, of the information: should we prefer a visual or verbal format? Another is whether it is contextual information; does it provide a reference point? Those two points will likely affect confidence and to what extent the anchoring effect will impact judgments. A further point is whether the decision maker's stage-of-change will affect perception. The hypotheses to be investigated are: formats that provide reference points through contextual information will increase confidence to make a judgment on CO₂ information; visual formats will perform better than non-visual formats; anchoring will have an effect on the perception of choices and the differences between them; and formats that provide reference points through contextual information will reduce the anchoring effect.

III. THE STUDY

In this study 45 people were asked to rank the sustainability of travel. The participants were recruited through a recruiting agency which selected individuals based on gender, age, usual transport mode, and if they had higher education or not. Along with the survey, the participants were involved in focus groups (six with roughly eight participants each) which further examined some of the issues discussed in this report. The survey was also completed by a larger international group which will be reported in a later paper.

In the survey four presentation styles, or formats, were used: weight, tree equivalents, earth equivalents, and a carbon budget (representing a cap and trade system). The order of formats was randomized to avoid the potential influence of learning as the participants progressed through the survey.

The participants were given three travel scenarios on each page (four pages in total) where the CO₂ information was presented in one of the four formats. To test for the anchor effects the participants were randomly assigned a survey with either examples of low per person CO₂ producers (a bicycle and a full bus) or larger CO₂ producers (a large hybrid with 1.6 passengers and a single occupancy 4x4). The third example in both cases was a full car to allow for comparison of results.

The hypotheses to be tested were:

- 1) Contextual information will increase the confidence of individuals in ranking the sustainability of alternatives - i.e. reducing the instance of “don’t know” (roughly how sustainable the travel scenario is) responses;
- 2) Visual information will improve comprehension, resulting in fewer “don’t know” responses;
- 3) Anchoring will have an effect on the perception of choices and differences between them;
- 4) Contextual information will reduce the impact of the anchoring effect.

In view of those four hypotheses, the four formats are discussed below.

Weight: All websites which use CO₂ information present at least the weight as this is the scientific measurement of the gas [3]. However, this format does not give context (reference point) and it is only text (verbal information).

Therefore, without giving some form of reference, it is anticipated that participants will struggle to respond to the ranking task. This will result in a greater number of “don’t know” responses and a greater influence from the anchor information.

Tree equivalents: A few websites used the number of trees required to sequester the amount of CO₂ produced as an equivalent representation of the gas weight. The tree format will visualize the information, but there is little contextual information. People are likely not aware of how many trees are “sustainable”. The trees should act to make the abstract concept of the gas more concrete which should help with comprehension as discussed above. People should be able to think of a tree, where they may struggle to think of 500g of CO₂. Although hundreds of tones of CO₂ can be represented by trees, that doesn’t make it necessarily sustainable. However, the scale of how many trees are necessary should help people more than weight alone.

The expected result is that fewer people will respond “don’t know” than for the weight format and some reduction (compared to the weight format) of the influence from anchors should be evident.

Earth equivalents: Some websites use the number of earths that would be required to sustain life if all people behaved the same as the individual being measured. This format should act to increase a sense of sustainability as one earth should act as a reference point. Modes that produce small amounts of CO₂ result in small slices while large producers may require more than one entire earth.

As well, there are the potential benefits of visualizing the information as discussed previously. The expected result is that people should have a greater sense of the sustainability of the mode which will result in few “don’t know” answers and less impact from the anchors as a result of the improved contextualization of the information.

Carbon budget: The carbon budget format presents the CO₂ information as a percentage of a fictitious limit, or cap. The percentage acts as a reference point to a limit, giving context to the information. The percentage should act as

clear figure, whereas the earth format may seem slightly ambiguous. However, the earth may benefit from being a visualization of the information.

It is anticipated that this format will reduce “don’t know” responses and the impact of anchors.

In summary, the expected results will be that carbon budget and earth formats will have the best results for confidence and the reducing the effect of the anchors. The visual tree format is expected to perform better than the more abstract weight format.

The tree equivalents used were based on results from American Forests (www.americanforests.org). A carbon allowance, or “budget”, of 3.6 tones was used based on results from the World Wildlife Fund’s footprint calculator (<http://footprint.wwf.org.uk/>). How people understand and react to the information was of concern and that same value was used for the earth equivalent to maintain consistency.

A number of individual characteristics are also considered in this study:

- Demographic: age group (20-34, 35-59, 60 years and up), education (higher education or not), gender (female or male);
- Environmental attitude/behavior: stage-of-change with respect to CO₂ reductions (don’t worry, don’t know what to change, will make changes in the next six months, made changes in the past year);
- Personal travel behavior: usual mode (car, other).

The descriptive statistics for those factors can be seen in Table I below.

TABLE I
Descriptive statistics of participants.

	N	Minimum	Maximum	Mean/Middle (n)	Std. Deviation
Age	45	21	76	47.04	16.7
Age groups	45	20-34 yrs (14)	60 yrs + (16)	35-59 yrs (15)	NA
Gender	44	Female (0)	Male (1)	.50	.50
Higher education	38	No (0)	Yes (1)	.55	.50
Stage of change	30	Don’t worry (6), Don’t know what to change (10)	Planning reduction (3), Made reduction (11)	NA	NA
Usual mode is car	45	No (0)	Yes (1)	.49	.50

The demographic characteristics are considered because age may affect the level of knowledge in this area with the youngest group anticipated to have a lower number of “don’t know” responses and be less influenced by the anchors. Having higher education may influence the level of awareness to climate change resulting in fewer “don’t know” responses and a lower impact from the anchors. The gender effect does not have an anticipated influence.

The environmental attitude/behavior measure of stage-of-change will be used as a proxy for relevance. Individuals who believe that such information is important may be less likely to answer “don’t know” as they may feel that they should be able to answer. It may also result in lower sustainability rankings as they may consider CO₂ in a more negative light.

Personal travel behavior may relate to how sustainable the travel scenarios are ranked with car users ranking things more sustainable than the other group. Mode use isn’t anticipated to have an effect on the number of “don’t know” responses.

IV. ANALYSIS AND RESULTS

Two measures were used for the analysis of variance (ANOVA): confidence and ranking. The first measure dealt with the confidence of the individuals to respond and was measured by the number of “don’t know” responses. The second measure examined the effects of presentation formats on the ranking of travel scenarios according to their perceived sustainability.

Confidence

This section examines results on how confident people were at “venturing a guess” as to the sustainability of a travel scenario. The participants were presented with a travel scenario that gave CO₂ information in one of the four formats and asked to rank it in terms of sustainability on a Likert scale from 1 (low sustainability) to 7 (high sustainability) with the option of answering “don’t know”. The participants were encouraged to “venture a guess” if they felt they could.

The first analysis examines the hypothesis that the more contextual information will have better confidence (i.e. lower “don’t know” occurrences) (Table II). As anticipated, the format weight was the worst performer, but surprisingly the earth format did not perform much better. The trees format performed best followed by the carbon budget. Those results do not support the hypothesis on contextual versus textual as the tree format (non-contextual) performed better than the earth format (contextual). However, from the focus groups we learned that for low CO₂ travel scenarios, the earth format was hard to understand and for some people results with more than 1 earth were “unbelievable” and thus meant nothing.

TABLE II

The average number of “don’t know” responses for each format (maximum is 3) *.

Weight	Trees	Earths	Carbon Budget
1.4	0.67	1.13	0.76

* Values are statistically different using one-way analysis of variance with no intercept. N = 180, F (4,176)=26.0, p< 0.001

What those results suggest is that the most common form of presenting information, as a weight, is the least likely to

give people the confidence to venture a guess as to how sustainable the travel scenario is. However, the contextual formats were not the best, with the equivalent format of trees performing the best. The focus groups discussions helped in explaining this result as people remarked that the use of trees was familiar and associated with the environment giving people confidence to give an estimate on the sustainability of the travel scenario. Few individuals commented that due to the lack of specific context, that they didn’t know how many trees could be managed.

As differences between the formats were observed, the next step is to examine what factors may influence those differences. With respect to the heterogeneity of populations, the influence of individual characteristics is considered here. The focus is on presenting CO₂ information by different formats for the purpose of increasing understanding, but the target audience is important. Individuals who are associated with a lower stage of change (e.g. they don’t worry about climate change) and drivers are the primary target with socio-demographic splits such as gender, age, and education also being considered.

The effect of the characteristics on the number of “don’t know” responses can be seen in Table III. People of higher stage of change did have lower number of “don’t know” responses as anticipated. Interestingly, car users had lower occurrences of “don’t know” responses for three formats. Females had considerably higher “don’t know” responses. Higher education had lower “don’t know” response as anticipated. Although not shown here, those results hold when gender and education levels are considered. The age group had the least consistent results across the different formats with the youngest performing best with the contextual formats and the eldest group performing best with the tree format.

TABLE III

The ratio of “don’t know” answers (out of three) for individual characteristics by format.

Comparison (n:n)	Weight	Trees	Earths	Carbon Budget
Don’t worry/don’t know what to change: Will reduce/Have reduced (19:11)	1.7 : 1.4	0.8 : 0.4	1.3 : 0.8	0.8 : 0.4
Usual mode is Car: Other (22:22)	1.3 : 1.5	0.6 : 0.7	1.3 : 1.0	0.7 : 0.8
Female: Male (22:22)	1.9 : 0.8	1.1 : 0.3	1.7 : 0.5	1.4 : 0.2
Higher education: other (21:17)	1.4 : 1.9	0.6 : 0.9	0.5 : 1.5	0.6 : 0.9
20-34 : 35-59 : 60 yrs + (14:15:16)	1.1 : 2.1 :	0.9 : 1.0 :	0.9 : 1.4 :	0.4 : 1.1 :
	1.1	0.2	1.1	0.8

* All results are statistically significantly different.

Sustainability Ranking

This section examines how anchor points affected sustainability ranking of the travel scenarios and whether contextual formats reduce that impact. 44 individuals were

randomly and evenly assigned to two streams of “low” and “high” CO₂ travel scenarios. The individuals in the “low” stream were presented with travel scenarios from modes that produce lower per person CO₂ amounts such as a full bus or a bicycle. The “high” stream included travel scenarios with motor vehicles carrying only the driver or 1.6 people (the EU average).

The results presented in Table IV show how sustainable the 500g per person for a 5 mile trip is perceived to be depends on what stream the participant was assigned to. The impact of seeing low CO₂ values resulted in responses towards the unsustainable end. Similar results are seen between the two population groups within the low stream. This suggests that what other information is presented will impact how people interpret information they are given.

TABLE IV

The average response of sustainability for the 500g (per person) for a 5 mile trip (objective value was 2) and the range was one to seven with 1 being “sustainable” and 7 “unsustainable.”*

Low CO ₂ Stream				High CO ₂ Stream			
Weight (n)	Tree (n)	Earth (n)	Carbon Budget (n)	Weight (n)	Tree (n)	Earth (n)	Carbon Budget (n)
6.82 (11)	5.78 (18)	5.20 (10)	5.93 (15)	3.14 (14)	3.00 (17)	3.25 (16)	3.06 (18)

* The responses of “don’t know” were removed from the data sets.

Analysis of variance (ANOVA) was performed with the dependent variable being the sustainability value assigned to a travel scenario presented in a specific format, and explanatory variables being the format for each stream. The results were that the format was significant in explaining differences ($p < 0.001$; adjusted $R^2 = 0.922$ for low; adjusted $R^2 = 0.695$ for high). However, when stream, format, and stream by format were considered then only the stream was significant ($p < 0.001$; adjusted $R^2 = 0.854$). This suggests that the effect of anchors is greater than the formats, which implies that people likely do have low prior knowledge for CO₂ information.

The change in responses between the two streams was used to examine if greater contextual information would reduce the effect of the anchor information. The differences were 3.68, 2.78, 1.95, and 2.88 for the weight, tree, earth, and carbon budget formats respectively. The earth equivalent showed the smallest change (1.95) in average answer between the two streams, suggesting that perhaps it does give better overall contextual information, but that its impact is limited. Surprisingly the carbon budget format did not have this same effect and performed worse than trees. Therefore, those results do not support the hypothesis that contextual information will reduce the anchor effect.

Those results lead to two arguments. One is that people don’t have a good sense of what is a sustainable amount of CO₂ and thus they rated the 500g for a five mile trip with respect to the other two scenarios given. The second is that,

even given contextual information, anchor information can still affect the perception of sustainability. From these results, presenting low CO₂ mode information will tend to make the other value appear larger (assuming that it is).

The next step is to consider the individual characteristics. Here each individual (22) is potentially answering four questions for a total of 88 responses. However, only answers that were not “don’t know” were included. For the low stream there were 54 remaining responses. Using that data set only gender ($p = 0.094$) and age group ($p = 0.064$) were significant. Females ($n = 32$) had lower answers (average 5.59) than males ($n = 22$, average 4.41). The oldest group ($n = 27$) had the lowest (average 5.37), followed by the middle age group ($n = 10$, average 6.40), and finally the youngest group ($n = 17$, average 6.53). The result for age might infer that the youngest group was perhaps the most pessimistic about the sustainability ranking.

For the high stream ($n = 63$) gender ($p = 0.007$) and stage of change ($p = 0.04$) were significant. Males ($n = 41$) ranked the scenarios lower on average (2.59) compared with females ($n = 22$, 3.95). For stage of change, those who “don’t worry” about climate change ($n = 26$) marked less sustainable (3.81) than the other three categories ($n = 37$, averaging below 3.0). Considering the different results for gender between the two streams, it may be that the men were more influenced by the anchors.

The results from both streams for the same scenario were analyzed using analysis of variance together with stream, format (weight $n = 23$, trees $n = 35$, earths $n = 26$, carbon budget $n = 33$), and gender (male $n = 63$, female $n = 54$) as the explanatory factors. The result was that stream ($p < 0.001$) and stream by gender ($p = 0.01$) were significant and explained more of the differences (as measured by the sum of squares) than the other factors. These results suggest that women are not as affected by anchoring than men. The format was not significant here, suggesting that anchors with consideration to gender are more important in influencing how sustainable something is perceived to be than the presentation format.

V. CONCLUSIONS AND RECOMMENDATIONS

The impact of CO₂ information format and information anchors on ranking the sustainability of travel scenarios was examined in this paper. The first hypothesis that formats that provide reference points through contextual information will increase confidence to make a judgment on CO₂ information was correct compared to purely providing the participants with weight, but did not hold in comparison with the CO₂ equivalent of trees required to sequester. The second hypothesis that visual representations would perform better than text was not found to be consistently true as although the tree format resulted in fewer “don’t know” response than weight, the earth format did not perform better than the text-based contextual format (carbon budget percentage). The third hypothesis on the anchoring effect was found to be true as a considerable difference in the sustainability ranking

between the two streams was found. The last hypothesis that contextual information would reduce the impact of anchors was not consistent. Although the earth format did have the smallest change, the carbon budget percentage performed worse than the tree format. Further in an analysis of variance with stream (anchoring effect), format, and gender, gender was found to be significant, but not format.

Following those findings and the review, the recommendations for the presentation of CO₂ information are: concretizing the information through visual equivalents increases confidence; what alternatives are presented needs to be considered as this will affect the perceived sustainability of the choices; the heterogeneity of the audience must be considered as gender will affect the perception of sustainability; if averages are presented, positive feedback must be included for people performing better than that averages.

Further empirical studies will be required to test the hypotheses in other contexts to provide further validation and understanding. Future research will consider how the presentation of information affects individuals' intentions and behavior in a travel choice context.

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