DOES "500g OF CO_2 FOR A FIVE MILE TRIP" MEAN ANYTHING? TOWARDS MORE EFFECTIVE PRESENTATION OF CO_2 INFORMATION

E. Owen D. Waygood*
* Corresponding author
Research Associate
Centre for Transport & Society
Faculty of Environment and Technology
University of the West of England
Coldharbour Lane, Bristol
UK BS16 1QY
Tel. +44.117.328.6435
Fax +44.117.328.3002

Erel Avineri
Reader
Centre for Transport and Society
Faculty of Environment & Technology
University of the West of England
Coldharbour Lane, Bristol
UK BS16 1QY
Tel. +44.117.328.3197
Fax +44.117.328.3002

Word Count: 6086 + 6 Tables + 1 Figure = 7836

ABSTRACT

Carbon dioxide (CO_2) emissions information is being presented to people in the hope that they will adjust their behaviour to reduce outputs. However, many might not fully understand or appreciate CO_2 information when presented as a mass; this might affect the interpretation and application of such information, and the individual motivation to travel in a more sustainable way. Related to that failing, this paper empirically examines two key questions. The first examines whether, depending on the format used (mass, trees, earths, and a carbon budget), people can give a sustainability ranking for various CO_2 emissions amounts. It is argued that the latter three formats each provide some degree of context which could increase the usability of the CO_2 information. Based on survey results, CO_2 information should be presented with greater context that just mass, ideally with respect to a recommended level. The second question examines the so-called anchoring effect. In a state of low knowledge, the way choices are valued is affected by contextual information such as those provided by other choices' attributes. If a format is able to convey enough contextual information though, this could stabilize interpretation. The anchoring effect was found to significantly influence the sustainability ranking of travel alternatives presented in all formats apart from the earth format. In general this suggests that the way travel alternatives are presented must be considered in the contextual design of CO_2 information or unintended interpretations may occur.

Keywords: carbon dioxide emissions, information, context, anchoring effect

INTRODUCTION

One strategy to reduce carbon dioxide (CO_2) produced by transportation is by affecting choice through better information. Providing information can be seen as both a service to users and as a means to change behavior. However, although sources for transportation CO_2 information exist, to date little research has looked at how it should be presented to be most effective. The available literature suggests that the most prevalent means of presenting CO_2 information, as a mass, is not useful to people. One problem is that people aren't familiar with CO_2 information, so they have difficulty interpreting the information. However, that information is occasionally presented in an equivalent form (e.g. as a balloon), which may help with interpretation by concretizing the abstract concept of CO_2 or by increasing context. Therefore, the first question investigated in this research is whether equivalents are more "useful" than simply presenting the mass of CO_2.

The second question considered relates to the influence of other choices. If people are uncertain about what something means, they may look for additional information, such as the amounts produced by other choices. If a travel choice is made (as opposed to habitual use), various options will be considered. Which options are considered will likely affect how sustainable each choice appears. For example, car pooling compared to single-occupancy vehicles will appear as the sustainable choice, but will appear worse if compared with using a bicycle. Therefore, the second question investigated here is to what extent do the choices we are presented with affect how sustainable something appears?

These questions are important to practitioners who are interested in using CO_2 information to assist with behaviour change towards more sustainable choices. The examples used are related to transportation, but the results are applicable to any tool that presents CO_2 information. The first question will help practitioners choose more useful presentations of CO_2 and the second question will determine whether what choices are presented should be considered.

BACKGROUND

Information about CO_2 is increasingly being used in transportation, but it is typically presented in its scientific form of mass. In the United Kingdom (UK), CO_2 information for cars is presented in grams/km and individuals around the world can estimate their CO_2 outputs for other modes through Internet tools such as carbon calculators or travel/journey planners which all use mass and only a few give additional information to help with interpretation *(1)*. Travel programs such as the Travel Blending in Australia *(2)* and the Travel Feedback Program in Japan *(3)* give feedback to users about various aspects of their travel including the mass of CO_2 emissions produced. Recent experiments involving CO_2 information in route choice and car purchase also used mass *(4)*. In all cases, the increased information is presumed to lead to more informed decisions, and to reduce CO_2 outputs, thus helping combat climate change. However, the assumption that CO_2 mass can be interpreted and applied by individuals may be questionable.

Despite the increasing presence of CO_2 information, there seems to be little research on whether people understand that information. Coulter et al. *(5)* found that both users and non-users of carbon calculator websites reported not really understanding the results when presented as mass. In their study, the users of such sites typically used it to either mark a starting point by which to measure reductions or to pay for an off-set. By attaching a monetary value to the mass, people may adjust their behavior or they may only ease their conscience and continue as before. Non-users were not typically interested in seeking out CO_2 information, but after using different sites, suggested that the format of "earths" was more easily understood with respect to sustainability and that they might make changes if given simple and clear advice on how to reduce outputs. Thus, rather than mass, an equivalent such as "earths" may be more useful and may even stimulate less environmentally-motivated individuals to change, but no empirical research has yet analyzed this.

Over 60 Internet tools that inform users of CO_2 production were reviewed at the ground work for the The Carbon Aware Travel CHoices (CATCH) project (*1*). These were examined for how CO_2 was being communicated and it was found that the *mass* of CO_2 is always used, but that occasionally

equivalents such as *trees* or *earths* were used, and in some instances national or demographically relevant *averages* were given.. As highlighted by Coulter et al.'s work, those different presentation styles may have varying levels of "usefulness" to individuals. Considering the problems of understanding CO_2 as a mass and the various other ways of presenting such information, it would be of benefit to practitioners to know which is most useful.

Considering why an equivalent such as an "earth" would be more useable, the issue of information content versus information context emerges. *Content*, here, is the mass of CO_2 produced by different travel alternatives. It is an amount, but the interpretation of that amount depends on the application of knowledge of what is a normal or desirable amount. *Context* is the additional information that allows the user to apply the content to some decision making process. Providing only the mass of CO_2 is providing content without context; the user reads the information, but doesn't know whether it's large or small, acceptable or not.

Equivalents may provide greater context to the information on CO_2 emissions. Rather than providing context through financial association such as offsetting, presentation styles could show what is sustainable. The presentation style of tree equivalents (the number of trees required to sequester the CO_2 output) visualises the rather abstract CO_2 gas, but is ambiguous about what is "sustainable" (i.e. how many trees could be planted every year to offset CO_2 production?). The presentation style of earth equivalents visualises the CO_2 information and attempts to show what is sustainable by showing how many earths would be required if all people behaved as the user. That contextualization of information may have been why the individual in Coulter et al.'s study felt that it was a useful format.

Along with contextualization, there may be further benefits to visualizing CO_2 mass. Images assist with the encoding of information *(6),* are good at concretizing abstract concepts *(7),* and improving the comprehension of scientific material *(8, 9)*. Of special consideration here is that images can also assist comprehension when the individual has low prior knowledge *(10)*. Through those various benefits, visualization of the CO_2 information may improve the usability of visual equivalents.

To increase the relevancy of CO_2 information to people, governments are contemplating cap and trade systems or tax systems related to CO_2 output. Cap and trade systems could change behavior by giving an acceptable limit and through market mechanisms. The acceptable limit set by the cap would help to create a reference point for people to judge whether a choice would be a gain or loss. Further, the use of a societal limit may act as guidance on what is socially acceptable. Reno et al. *(11)* define such information as *injunctive norms* which have been found useful in household energy use studies *(12)*.

Improving understanding through context may increase the usefulness of the CO_2 information, but people will likely still be operating in a state of low knowledge. When an individual is uncertain about a number, additional numbers, even random ones, will affect estimations. This effect was termed *the anchoring effect* by Tversky and Kahneman *(13)*. Due to the relative "newness" of CO_2 information, people are likely acting in a state of uncertainty about how sustainable their motorized travel choices are. In a high state of uncertainty other alternatives could make certain choices appear more or less sustainable.

To help explain the relevance of the anchoring effect to CO_2 emissions information, consider this analogy. You eat food everyday (the action), and depending on the food you receive a certain number of calories (the impact). Your body needs a certain number of calories (the budget), and an excess of calories will result in weight gain that over time could lead to major health problems. Now, imagine that you don't know how many calories your body needs and you are contemplating what meal to have. There are a few meals that you could eat and you're given the total calories. They are 1200, 1500, and 2100 kcal. In this situation, 1200 kcal seems low. However, if the options were 300, 600, and 1200 kcal, the same 1200 kcal would now seem very high. The role of the options acted to influence interpretation, effectively pulling one's interpretation either higher or lower.

Now, if the calories were given with some contextual information, such as the percentage of a normal daily diet, then perhaps the anchoring effect would be reduced. In such a situation, one would see that 1200 kcal was about half of one's daily calorie requirements. The contextual information would then allow the individual to make a more educated decision on whether it was an appropriate choice for them.

With consideration to that, could a contextual format reduce the anchoring effect for CO_2 information? Presumably yes, but CO_2 considerations may be so new and uncertainty so high that the anchoring effect may still be large. This is an important consideration to practitioners who present CO_2 information to decision makers. If contextual information eliminates the anchoring effect then no consideration to what alternatives are presented in a choice set is necessary. However, if contextual information cannot eliminate the anchoring effect, then attention should be paid to what alternatives are presented as they will affect interpretation of sustainability, which will then affect such considerations in final choices.

Background Summary

CO_2 information is typically being presented in transportation situations as mass, but past research suggests presenting the mass of CO_2 is not useful to people. This may be a problem of lack of background knowledge and context to support interpretation. In such a situation, the information may be ignored or if it is considered, the attributes of the choice set will likely affect interpretation (the anchoring effect). Providing greater context may improve interpretation and could possibly reduce or eliminate the anchoring effect.

RESEARCH FRAMEWORK

The previous section described why context is likely important to understanding and interpreting CO_2 emissions information. This section describes the theoretical framework used to understand the choice process.

As in prospect theory *(14)*, we also suggest that when people are making choices they simplify information. Rather than retain and consider exact amounts, people likely assess information as being desirable or undesirable. Put another way, they interpret the information as a gain or a loss. They determine if it is a gain or loss by comparing it to an internal reference point. Using the food example again, if the objective of a person was to avoid excess calories, then their reference point for daily consumption might be 2500 kcal. They might then code a single meal of 500 kcal as "acceptable", 1200 kcal as "avoid," and 2100 kcal as "not to be considered". With that interpretation, their choice set would then likely be the first two items and other considerations such as cost and desirability would lead to a choice.

The first stage of that process, the coding, occurs in the *editing phase* as defined by Kahneman and Tversky *(14)*. The second stage where all the attributes (e.g. calories, cost, and desirability for the food example) are considered is termed the *evaluating phase,* which then leads to a decision, or choice. This paper will focus on aspects related to the coding process of the editing phase. It will examine the influence of context on the ability to facilitate the coding process by evaluating whether a ranking was given or not. The second question looks at how the ranking (i.e. coding) is affected by other examples.

However, prior to even the editing phase, a person likely must value the information in order to consider it. In the health field, the stages of change theory *(15)* suggests that there are six stages from pre-contemplation (unaware of problem, no intention to change) through to termination (behavior change complete and relapse unlikely). Depending on the stage-of-change, different information will be relevant and thus valued and considered. An environmentally aware individual who has already adjusted their behavior may put more effort into interpreting it. As well, they may also have greater background knowledge and experience with CO_2 information. Therefore, a person's environmentally sustainable behaviour should also be considered.

METHOD

The first question investigated relates to whether contextual information facilitates coding. Three different presentation styles, or *formats*, that have some degree of context were considered in comparison to mass. The sustainability ranking was a seven-point Likert scale with the most sustainable option at one end and the least sustainable option at the other with a further "don't know"

option. The format's ability to facilitate the coding process can be measured by the number of "don't know" responses.

The specific question was: *does the format affect whether the participant ranks the travel scenario*? This question assumes that a person needs to first be able to make some kind of ranking before they could compare it to their reference point to establish whether it would be a gain or loss. By analyzing whether format will affect the ability to rank, this research will highlight more useful presentation styles.

The second main question deals with the anchoring effect and context. The anchoring effect may impact how the travel scenarios are ranked, which could affect how they are coded in the editing phase. If consideration to what alternatives are presented is *not* made in the design of information systems, then it would be important to reduce the anchoring effect so that people would code information appropriately no matter the other alternatives presented. Potentially, contextual formats such as the earth format may reduce the anchoring effect. This is because an acceptable range is communicated through the context, which should reduce the tendency or need to compare with other information to make a judgement of acceptability. Thus, the second question investigated in this paper is: *do contextual presentations of CO_2 reduce the anchoring effect*? This question is important as it will highlight whether the choice set shown to individuals will affect their understanding irrespective of the format used.

Participant Characteristics Considered

A number of characteristics were thought to be important considerations in this research. These include valuing the information, age, education, country of residence, and usual transportation mode. As previously mentioned, people will not likely consider information that they do not value. If CO_2 information is relevant (person is at least aware of the problem), individuals may put more effort into interpreting it. Those who have already made changes to lower their environmental impact may feel that they *should be able* to give a sustainable ranking. That second point is related to the theory that individuals want to be consistent *(16)*; that once they have a made a decision they will act to support that decision. It may also result in lower sustainability rankings as they may consider CO_2 with greater concern. This aspect was measured by asking the individuals to choose the statement that best described them:

- I don't worry about climate change.
- I worry about climate change, but don't know what to change.
- I worry about climate change and I am planning to reduce my impacts.
- I have made changes in the last year to reduce my impacts.

Demographic characteristics are considered because age may affect the level of knowledge in this area with the youngest group thought to have greater exposure, thus ranking the information more often and be less influenced by the anchors. Having higher education may influence the level of awareness to climate change resulting in more frequent ranking and a lower impact from the anchoring effect. The country of residence may affect awareness and concern about environmental problems such as climate change. Therefore that factor is also included, though no conjecture of the impact of each country will be made. Finally, gender is included, though there is no anticipated influence.

Personal travel behavior may relate to how sustainable the travel scenarios are ranked. It is anticipated that car users would rank the travel scenarios as more sustainable than others to reduce feelings of guilt (if they are concerned about the environment). That is predicted based on the theory of cognitive dissonance which suggests that people will act to reduce conflicts between actions and/or beliefs so as to avoid the negative feelings of such inconsistencies *(17)*.

In summary, the hypotheses tested are:

1) Contextual formats will increase the likelihood of ranking.
    a. The characteristics of the participants *age* (-), *higher education* (+), and *environmental stage of change* (+) will affect the likelihood of ranking.

2) Contextual formats will reduce the anchoring effect of what other choices are presented.

a. The characteristics of the participants *environmental stage of change* (-) and *usually drive* (+) are anticipated to affect the ranking.

The survey

In this study 194 people (Table 1) were asked to rank on a seven point Likert scale the sustainability of travel scenarios presented in four different formats. The majority of the respondents participated through their workplaces which were involved in the CATCH project in five different countries (Brazil, England, Italy, Scotland, and Spain). For the analysis, Scotland and England are combined as the UK. A smaller set of 45 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. Those individuals participated in focus groups which included discussion related to the survey.

TABLE 1 Descriptive statistics of participants.

Factors	N	Percentage
Age (years) **(Min=19, Max=76)**		
20 to 34 years	88	45%
35 to 59 years	79	41%
60 years and over	22	11%
Male	100	53%
Higher Education	112	61%
Usual mode is car	136	73%
Nationality		
UK	88	45%
Brazil	30	30%
Spain	26	13%
Italy	50	26%
Stages of change		
Don't care about climate change	25	13%
Care, but don't know what to change	42	22%
Care and am planning to change	54	28%
Care, changed something in the past year	55	28%
Low CO_2 alternatives Stream (anchoring effect)	98	50.5%

To facilitate the research on anchoring effects the participants were randomly assigned to either a low or high stream. The low stream had travel scenarios based on modes which produce smaller amounts of CO_2 per passenger. The high stream had travel scenarios which produced larger amounts of CO_2 per passenger. To investigate the potential impact of formats on the anchoring effect one travel scenario was included in both streams with the same CO_2 information. The examples used in both streams are shown in Table 2.

TABLE 2 The example travel scenarios for a five mile trip used in each stream.

Stream	Mode represented	CO_2/passenger for 5 mile trip
Low	Bicycle*	132g (4.66 oz)
Low	Full city bus	230g (8.1 oz)
Low, High	Full car	500g (17.6 oz)
High	1.6 passengers in large hybrid car	1100g (38.8 oz)
High	Single occupancy 4x4	3000g (105.8 oz)

* This is based on work by Lane (2006) that estimated the calories required and the associated CO_2 produced by an average UK diet to supply those calories.

As mentioned previously, four formats were explored: mass, tree equivalents, earth equivalents, and a carbon budget (representing a cap and trade system). The participants were given

three travel scenarios on each page (four pages in total) where the CO_2 information was presented in one of the four formats (Figure 1; high stream). They were not told what the mode was so as to eliminate inferences they may have associated to the mode.

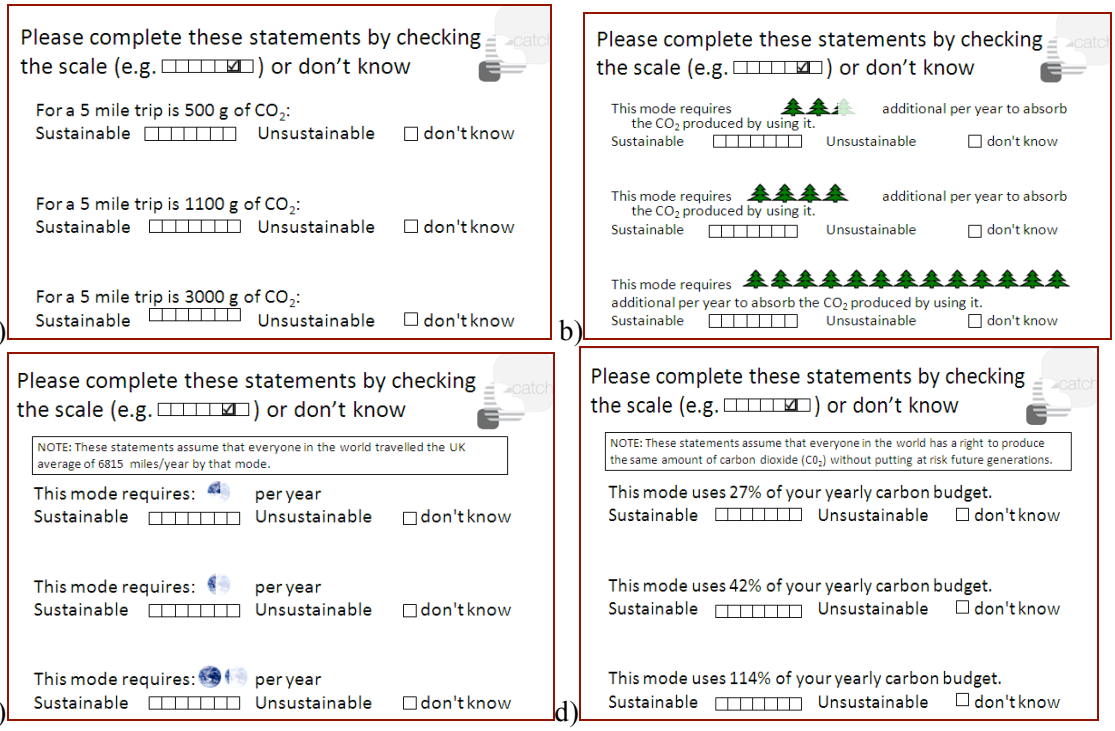

FIGURE 1 The larger CO_2 producing travel scenarios. a) Shows the mass format (no context). b) Shows the tree equivalents format (some context). c) Shows the earth equivalents format (high context). d) Shows the carbon budget format (high context).

The anticipated impact of each format (compared with mass) on the two main hypotheses are shown in Table 3. Summarizing those impacts, the expected results will be that carbon budget and earth formats will result in more participants ranking the travel scenarios and reduce the effect of the other travel scenarios presented to pull the ranking in one direction or the other (anchoring effect) as those two formats contextualize the information with respect to some limit. The tree format is expected to perform better than the more abstract mass format, but is expected to have limited impact on the anchoring effect as it does not directly indicate a limit.

TABLE 3 The anticipated impact of presentation format on usability and anchoring.

Format	Anticipated impact on usability	Anticipated impact on anchoring effect
Mass	(baseline)	(baseline)
Tree equivalent	+	None
Carbon budget	++	Reduce
Earth equivalent	++	Reduce

The amount of CO_2 produced for each travel scenario was estimated using travelfootprint.org *(18)*. The yearly amounts were based on the UK average mileage of 6815 miles *(19)*. The tree equivalents used were based on results from American Forests (www.americanforests.org). A carbon allowance, or "budget", of 3.6 tonnes was used based on results from the World Wildlife Fund's footprint calculator (http://footprint.wwf.org.uk/) (the authors do not suggest that 3.6 tonnes is a sustainable amount or that it is recommended cap level). How people understand and react to the information was of concern and thus the same value was used for the earth equivalent to maintain consistency. That consistency should allow for better comparisons between those two formats.

ANALYSIS AND RESULTS

Analysis was first carried out that examined purely the impact of the formats, and then potential influences of the participants' characteristics were examined. For each format, there were three ranking questions. The action of ranking was used here to measure usability. Therefore, the dependent variable was the number of these that *were ranked*.

First Hypothesis: Contextual Formats will Increase Usability

For the first hypothesis analysis of variance (ANOVA) was used to examine whether the number of ranked responses differed across the formats. In terms of the first hypothesis, format had a significant main effect with the average number of ranked responses being: mass 70.3%, trees 80.2%, earths 72.7%, and carbon budget 83.8% (N=776, F(3,772)=4.615, p=0.003). However, although significant, the effect size was small (partial eta squared = 0.02). Examining the Tukey HSD test, only carbon budget ($M = 2.5$, $SD = 1.08$) was significantly ($p < 0.05$) different from mass ($M = 2.11$, $SD = 1.35$)

The tree format, though concretizing the concept of CO_2 mass, does not provide contextual information with respect to a limit. However, the earth format does convey a limit and so the result that it was not statistically more usable (in terms of ranking sustainability) than the mass format was surprising. One possible explanation of this result comes from signal detection theory *(24)* applied to research on graph presentation *(20)*.

Signal detection theory is a general framework that is used to describe and examine decisions made in uncertain situations *(21)* and distinguishes between the signal and noise. For the earth format, the signal is the portion of the earth with full color and the noise is the remaining portion (if under 100%) that is faint in color. People may have experienced difficulty detecting the signal. Holland and Spence *(20)* found that people had greater difficulty with pie charts to distinguish differences, particularly when the differences are small. In that manner, the use of the earth presentation format is expected to have the same weaknesses experienced in using pie charts to represent choice attributes: individuals are less likely to detect the difference between two information items that represent small values of CO_2 emissions.

The focus group results support that possibility as several individuals who were in the low stream commented that they had trouble detecting and distinguishing differences of the small pie slices. Future research should examine whether the problem is with the earth format itself, or the presentation style used in this experiment.

Two-way, between groups analysis of variance was used to examine the other potential influences on ranking. The results are listed in Table 4 and in all cases Levene's Test of Equality of Error Variance was significant, so only results that are $p < 0.01$ are considered statistically significant. No interaction effects were significant, so the main effects can be directly interpreted.

TABLE 4 Results of two-way, between groups ANOVA for format combined with the other considerations.

Variable (number of categories)	Variable Effect *p*	Format Effect *p*
Age Group (3)	n.s.	0.007
Gender (2)	n.s.	0.004
Education (2)	n.s.	0.002
Stage-of-Change (4)	< 0.001	0.001
Usual mode is car (2)	n.s.	0.007
Setting (2; N = 352)	n.s.	0.006
Country (4)	0.003	n.s.
Stream (2)	0.009	0.003

N = 776

The conjecture about the youngest age group (20 to 34 years) ranking the travel scenarios more often was supported by the difference as compared to the middle age group (35 to 59 years), but not the eldest group (60 years and over). The conjecture about the impact of higher education on the likelihood to rank was not supported. Males were more likely to rank than females. The country of the respondents was found to be significant. Only the UK respondents were statistically significantly different from the other countries (overall $M = 2.31$, $SD = 1.24$); they were less likely to rank ($M = 2.13$, $SD = 1.33$). In order to consider whether this was an impact of the setting (focus group versus work), only UK respondents were compared for the *setting* variable, but the effect was found to be insignificant.

The hypothesis that participants in higher environmental stages-of-change would be more likely to rank was supported by the results with the two higher self-reported stages (care about climate change and will change something or have changed something) being more likely to rank (mean values in order of increasing stage of change were: 1.94, 2.18, 2.54, and 2.42). This result supports the proposal that valuing the information will increase the chance that the information will reach the coding stage in the editing phase which then leads to the evaluation phase (Figure 1). As well, the effect size was largest for stage of change (partial eta squared = 0.03).

Unexpectedly, the stream (low or high) which the participant was randomly assigned to was found to have an impact on "don't know" response rates. The higher levels of CO_2 stream were more likely to respond ($M = 2.42$, $SD = 1.16$) than the lower ($M = 2.19$, $SD = 1.31$). However, the effect was extremely small (partial eta squared = 0.01).

In summary, the main effect of format was found to be a significant explanatory variable in different rates of ranking, but not as anticipated. There was no clear benefit of just improving context as the earth format performed poorly. However, it was confirmed that the most dominant format, mass, is the least useful. As well, the notion that valuing the information (as measured by stage of change) would increase the likelihood of reaching the editing phase (e.g. ranking) was found to be significant. The country of residence was also significant with the UK ranking less often than all of the other countries. This may be the result of different overall levels of awareness or concern.

Second Hypothesis: Contextual Formats Reduce the Size of the Anchoring Effect

One travel scenario was included in both high and low streams with the same CO_2 information in order to investigate the potential impact of contextual formats on the anchoring effect. Only rankings were considered, so responses of "don't know" were eliminated.

ANOVA analysis was used for each format to test whether the anchoring effect was a significant main effect in explaining different rankings. The potential range was 0 to 6 (Likert scale of 1 to 7). All results (Table 5) were significant at $p < 0.001$ which suggests that regardless of the format, there was an anchoring effect evident due to the presence of other example travel scenarios.

TABLE 5 The mean values of sustainability rankings for the different formats by stream (high = the alternative travel scenarios produced large amounts of CO_2 per passenger; low = the alternative travel scenarios were small amounts of CO_2 per passenger.)

Format	Other values high	Other values low	Difference
Mass	6.3	3.7	2.61
Tree	3.3	5.3	2.02
Earth	4.5	5.2	0.67
Carbon Budget	3.2	5.8	2.59

The interest is perhaps in the difference (Table 5) between the average rankings for each format by stream. Those results suggest that the Earth format reduced the impact of the anchoring effect, but that was not the case for the carbon budget as well, so the hypothesis that the contextual formats would reduce the impact in comparison to the other two was not supported.

The next analysis considered whether characteristics of the participants affected ranking. The participants' characteristics along with the stream were considered using two-way, between groups ANOVA. Results were split by format as stream and format had high interaction effects.

TABLE 6 Two-way, between groups analysis by format for stream in combination with personal characteristic variables.

	Mass		Tree		Earth		Carbon Budget	
Variable (number of categories)	Variable Effect *p*	Stream Effect *p*	Variable Effect *p*	Stream Effect *p*	Variable Effect *p*	Stream Effect *p*	Variable Effect *p*	Stream Effect *p*
Age Group (3)	n.s.	< 0.001	n.s.	< 0.001	n.s.	.037	n.s.	< 0.001
Gender (2)	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001
Education (2)	n.s.	< 0.001	n.s.	< 0.001	n.s.	n.s.	n.s.	< 0.001
Stage-of-Change (4)	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001
Usual mode is car (2)	n.s.	< 0.001	n.s.	< 0.001	n.s.	n.s.	n.s.	< 0.001
Country (4)	n.s.	< 0.001	0.043	< 0.001	< 0.001	n.s.	0.018 (n.s.*)	< 0.001
Setting (2; N = 352)	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001	n.s.	< 0.001

* The Levene's Test of Equality of Error Variances was significant.

No variable considered for the mass format was able to explain variation when *stream* was considered as well. This supports the prediction that people have low background knowledge and are thus operating in a high state of uncertainty and the anchoring effect's influence will increase with the non-contextual format of mass.

For the format *tree* the UK and Brazil had larger changes between the high and low streams compared to the respondents from Italy and Spain. This may be a cultural artefact with the two former countries having a high association between trees and the environment. However, that was not investigated here.

Continuing with the format *tree*, *gender* also had an interaction effect with *stream*. The average ranking changed for men by 2.74 steps, while for women it only changed by 1.06. It is not clear why this may be, but it may relate to different evaluation strategies.

For *earth*, there was no statistical difference between the streams when *car-use*, *stage of change*, *age group*, or *country* were considered. In those cases, only *country* was statistically significant with the UK being the only country where the average response was considerably different between the streams (1.6 versus 0.2 in all others). This was not an effect of the setting (focus group versus work) as this was also investigated and found to be insignificant. It would seem that the residents of other countries benefited from the contextual information that the earth format gave.

Continuing with *earth*, *gender* also had an impact. A similar result to *tree*s was found with the average result for men changing by 1.35 compared with 0.19 for women. However, this result was not repeated in for the *carbon budget* format. This may suggest some different interpretation between genders of more abstract concepts such as tree or earth equivalents.

For the *carbon budget* format, only *country* potentially had a significant effect. However, the Levene's Test of Equality of Error Variances was significant, suggesting that variance of the ranking across the groups was not equal and a stricter significance level should be used. Therefore, this result should not be considered significant.

With respect to the predicted impacts of the stage of change and mode use, neither was found to have a consistently significant effect on the ranking. The result for the stage of change suggests that it is effort rather than experience that explains higher response rates for the first hypothesis on the coding process. For the mode use, it may be that as the travel scenarios are not examples of the individual's actual travel, cognitive dissonance does not apply.

DISCUSSION

Providing individuals with information about attributes of their travel choices, such as carbon emissions might be seen not only as a service provided to the public, but as an instrument to change travel behavior. The presumption is that individuals, provided with travel information, can make more fully informed choices which will be to their personal advantage and potentially that of the transport system as a whole. In the economic tradition, where the assumption of perfect information is a necessary part of rational decision-making, information systems are therefore a necessary part of choice.

However, the design of travel information systems has often ignored the psychological, ergonomic and cognitive processes of retrieving and using information. The factors that might play a role in behavioral change processes are not always addressed in the design of such systems. The findings of this research first suggest that the dominant format of using CO_2 mass to inform decision makers is not very effective with nearly a third of all responses being unranked. The best format by that measure was the carbon budget, based on a cap and trade concept. That format likely worked best because it gave context to the information; it gave the decision maker a reference point to work with. However, the other contextual format, earth, did not perform well in this aspect but may have suffered problems of interpretation related to the presentation style. From those findings, simple, contextual formats should be used in the design of CO_2 information systems.

Environmental stage of change, country, and stream were all significant in explaining the potential to rank as well. This highlights the need to consider the general level of awareness of the population. A single format is unlikely to be sufficient to communicate effectively with all citizens in all countries.

No format was found that consistently eliminated the anchoring effect. This finding suggests that practitioners must consider what alternatives are being presented as they will affect how sustainable the different choices appear. This is especially true at the present time when knowledge is low for what acceptable levels of CO_2 are.

The *earth* format was able to eliminate the anchoring effect in a number of two-way interactions though. This suggests that if the usability (as measured by the occurrence of ranking) could be improved it may be a very effective format and reduce the complexity of design.

This research was not able to use samples that were wholly representative of each country's populations, heavily favouring employed individuals. However, employed individuals likely have greater financial capacities which may increase resource consumption, making them an appropriate target for CO_2 reduction campaigns. Actual impacts on choice or behavior change were not investigated which, along with a larger sample, are important future research considerations

Some perhaps unrealistic expectations of big effects from new information systems have remained unrealised *(22)*: in practice, detailed information tends to be sought after a decision to change behavior (or to consider changing behavior) for other reasons *(23)*. Considering that, information provided about a trip or route supports, as opposed to stimulates, behavior change. Many journeys are routine, familiar and predictable and correspondingly there is not a demand for information use in relation to travel choice. However, Chorus et al. *(22)* in a review of the impact of information on transportation choices found that post-trip information can be effective in changing future travel behavior.

Considering that and the results of this research, in order to make the use of information more effective in promoting sustainable travel practitioners should:

a) Motivate people to seek CO_2 information or, create uncertainty that one's choice is the correct one to stimulate the person to seek information on CO_2.
b) Include post-trip CO_2 information.
c) Use formats that facilitate coding as good (gain) or bad (loss).
d) Present alternative choices that stimulate desirable change to lower carbon choices.

CONCLUSIONS

Carbon dioxide (CO_2) information is available for individuals, but its usability has not been investigated. This research investigated whether the CO_2 information presentation format affected the ability of individuals to give a sustainability ranking and whether anchoring effects were affected by

the formats. There were four formats tested that represented textual/visual and non-contextual/contextual presentation styles. The study population was from five countries and favoured employed individuals.

Analysis of variance found that the main effect of format was important in explaining whether or not the travel scenario was ranked, with the textual-contextual format of carbon budget (representing a cap and trade concept) being associated with the most rankings. The results highlight that the current practice of using mass to convey CO_2 information is not as effective as other formats could be.

Along with the format types, characteristics of the participants were also analysed. For the likelihood of ranking, *age*, *gender*, *environmental stage of change*, and *country* were all significant. This indicates that heterogeneity in the population and the population's level of awareness are relevant considerations in communicating CO_2 information by practitioners.

It was hypothesized that contextual formats would reduce the impact of the anchoring effect. However, although the earth format had the lowest difference between the high and low streams the other contextual format, carbon budget, was not statistically different from the mass format (the most affected by the anchoring effect). For practitioners, this suggests that alternatives could be used to highlight the desired choice.

Some limitations of this research were discussed above which suggest that to validate these findings future research should aim for larger scale research in more realistic settings. Other considerations include how information should be provided if it is not being actively sought (e.g. metering CO_2 produced while driving). As well, how should people be stimulated to value such information (e.g., providing incentives, cap and trade, or making it "the right thing to do")? Building on that, research on evaluation and actual behavior change is necessary to best guide the design of information tools and campaigns.

ACKNOWLEDGMENT

This work was sponsored by the European Commission's Seventh Framework Programme (FP7) through the Carbon Aware Travel CHoices (CATCH) project.

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