Transportation Research Part D 19 (2013) 28–33

Contents lists available at SciVerse ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Understanding carbon: Making emissions information relevant

William Brazil [a], Brian Caulfield [a,*], Nadine Rieser-Schüssler [b]

[a] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin 2, Ireland
[b] Institute for Transport Planning and Systems, ETH Zurich, Zurich, Switzerland

ARTICLE INFO

Keywords:
Carbon emissions
Environmental communication
Carbon calculator
Emissions information

ABSTRACT

This paper examines methods of communicating and presenting information to individuals about transport and travel related carbon emissions for use in online journey planning and smartphone applications. It examines four methods of framing transport related emissions and the effect of these on ease of understanding and the potential to alter respondents' mode of transport. On-line carbon calculators provide users with information about the carbon emissions that result from the selection of one mode of transport over another. Each reflects an approach currently used by on-line carbon calculators. Results indicate that there is a strong correlation between understanding of methods and likelihood of altering mode choice.

1. Introduction

Carbon dioxide (CO_2) emissions arising from human activities are now widely accepted to be a cause of accelerated global climate change. Personal transport and travel is an area where individuals can make conscious choices that have a direct impact on their personal carbon footprint by changing their transport mode. Often more immediate concerns such as personal travel time and cost can take precedent over concerns about the environment.

Many individuals are also "locked" into certain habits that take precedence over environmental concerns when considering mode choice. The result of which is that while individuals may have an intention to modify their travel behaviour and may also have access to feasible low carbon alternative modes, they do not consider these alternatives when undertaking a trip, rather they operate on "autopilot" (Gardner, 2009). One solution to this problem has been identified as the provision of accurate, personalised carbon emission information in a format that is easily understood and relevant to the individual (Anable et al., 2006).

Previous studies have looked at emotive carbon equivalents such as offsetting by planting trees and "earth equivalents" (Waygood and Avineri, 2011), whereas here we examine techniques commonly used by online carbon footprint calculators and journey planners with specific reference to their potential application for smartphone applications and journey planners. The ease with which users can understand information regarding carbon emissions, and how the format of this information influences the likelihood of behaviour change is examined through the comparison of four methods of emissions information framing.

2. Method

A survey was undertaken in the greater Dublin Area to assess user requirements for a persuasive travel advisor with the aiming of reducing travel related CO_2 emissions. It took the form of an on-line questionnaire distributed via a number of

* Corresponding author. Tel.: +353 1 8962534.
E-mail address: brian.caulfield@tcd.ie (B. Caulfield).

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http://dx.doi.org/10.1016/j.trd.2012.12.002

sources including the electronic notice boards of semi-state organizations. Four hundred and fifty seven responses were received; a completion rate of 77.6%.

Due to way the survey was distributed, the sample cannot claim to be representative of the Irish population as a whole. The sample has more respondents in the higher brackets for education and employment type than would be expected from Irish census data for 2011 (Central Statistical Office, 2012), and more female respondents (54.4%). It is likely that the electronic questionnaire format would have been more accessible to those individuals engaged in office based employment with consistent access to information systems than those engaged in manual labour. While there are a number of issues surrounding the use of online surveys, in particular with regard to sampling biases, we assume that is somewhat mitigated by the nature of the study area. Smartphone applications of this nature are more likely to be accessed by individuals who already possess an interest or concern about the impact of their transport behaviour on the environment. These individuals may not constitute the whole population. When the survey was distributed, it was clearly communicated that the survey dealt with these issues, and, therefore, we assume that individuals completing the survey share some of the same characteristics as the sub population we are hoping to capture.

Survey respondents were presented with four methods of understanding carbon emission arising from their trips (see Fig. 1). Each presented respondents with information on the attributes of bus, driving and heavy rail. As our purpose was to examine how carbon emissions information could be integrated into a smartphone application interface, information on travel times and trip costs associated with each mode were also presented as these attributes are likely to be included in any transport related application. The approach was based upon methods already being employed by journey planning applications and carbon calculators. To ensure that respondents were aware that they were being asked to assess the method of presenting emissions, rather than choose the mode they would take, the attribute levels for each mode (time, cost and emissions) were kept constant for each method.

- **Method 1**, the "Basic Numerical Method", presented respondents with simple numerical information regarding the emissions that would be produced by each mode. Emissions information was presented in terms of mass in kilograms of CO_2 produced by each mode with no additional information available to the user. This format be similar to the approach taken by many carbon calculators and is comparable to methods of communicating other intangible units such as calorie information on the packaging of food products.

Fig. 1. Methods used to display emissions.

- **Method 2**, also known as the "Light Bulb Method", contained the same information as provided in Method 1 as well as additional information designed to help respondents put their emissions into context. Respondents were told how long a 60 W incandescent light bulb would need to be left turned on to produce the equivalent amount of emissions of CO_2 as their trip. This calculation was based upon the current Irish electricity mix (Howley et al., 2009). The choice of the 60 W bulb was due to a number of factors including the simplicity of the device, the status of light bulbs as iconic images in previous energy saving campaigns, and its widespread use in Irish homes until very recently. This method is similar in nature to the approach taken by Caulfield and Brazil, 2011) and the Traffic Scotland carbon calculator (www.trafficscotland.org/carboncalculator/). Although it could be argued that comparing emissions in terms of kilograms with lightbulbs is merely substituting one abstract concept for another, precedents already exist such as the conversion of calories to Weight Watchers Points in the food retail sector (www.calculator.net/weight-watchers-points-calculator.html). Accompanying images were merely illustrative and did not relate directly in scale to the emissions produced.
- **Method 3**, the "Carbon Budget Method", presented respondents with the same basic information as provided in Method 1 as well as additional information regarding a daily carbon budget. The principle advantage of this method that it provides the user with a frame of reference that may not otherwise have been present. The idea of personal carbon budgets is already well developed in terms of the concept of enforced carbon budgets and personal carbon trading schemes (Bristow, 2010). It is similar to the planets method used by the World Wild Life Fund carbon calculator (http://footprint.wwf.org.uk/) but differed in that it presented users with a daily rather than annual budget and was trip specific allowing users to isolate the impact of a unique choice rather than a lifestyle as is the case with the WWF approach. This budget was based upon McNamara and Caulfield (2011) and assigned respondents a hypothetical daily carbon budget of 5 kg per day for travel activities, which could be divided across modes. The budget is purely informative and is unenforced, meaning that users suffer no quantifiable personal loss for exceeding their limit such as a fiscal penalty.
- **Method 4**, the "Traffic Light Method", was constructed so that while it contained the same information as the other methods with regard to travel time and trip cost, it omitted specific information on carbon emissions. This was intended to test whether respondents had a preference for visual rather than quantitative information on carbon emissions. Instead of numerical information, Method 4 provided respondents with a traffic light colour coding system where the highest emitting mode was assigned a red light, the medium mode a yellow light and the lowest emitting mode a green light. This method reflects the approach being taken by a number of carbon calculators such as the Dutch website CBS.nl (www.cbs.nl/en-GB/menu/themas/natuur-milieu/cijfers/extra/footprint.htm), as well as the use of traffic light style colour coding in the white goods and building energy sectors in Ireland and the EU. Although it appears there is a bias in terms of survey design, as the method was the only one that did not provide numerical information, this reflects the format of internet based carbon calculators examined, the majority of which provide numerical information in some format.

All the methods outlined above and the majority of those employed by other carbon calculators assume an existing level of knowledge of the mechanics of carbon dioxide emissions and climate change. Users may not need to understand the precise mechanics of the situation, in terms of how molecules of carbon dioxide interact to trap heat within the atmosphere, however to make use of the information provided they must at least understand that increased carbon emissions are related to increased levels of climatic instability. These methods also rely on the individual actually wishing to undertake behaviours that reduce emissions. It can be assumed, however, that individuals who use smartphone applications and websites providing environmental information have at least some desire to alter their behaviour, or at least receive information on the consequences of their actions.

3. Results

After viewing the four methods of carbon presentation respondents were asked to indicate which method they had found the "easiest" and "hardest" to understand and which method was "most likely" and least likely" to entice them to move to a lower carbon emitting mode. This question format forced respondents to make a choice between methods, while also addressing some of the issues of response similarity that may occurs with Likert scales.

Table 1 shows the respondents' preferences for each method of displaying carbon emissions both in terms of understanding them, and their likelihood to influence mode choice. Basic numerical information using Method 1 is the easiest understood and the most influential method. The Traffic Light Method has been selected as both the method that is hardest to understand and least influential by largest section of respondents. The Carbon Budget Method was chosen as the hardest

Table 1
Perception of methods.

	Basic Numerical (%)	Lightbulb Method (%)	Carbon Budget (%)	Traffic Light Method (%)
Easiest method to understand	37.7	28.2	17.7	16.3
Hardest method to understand	14.6	16.1	29	40.3
Most likely to alter mode	32.7	28.5	24.5	14.1
Least likely to alter mode	16.1	15.2	21.4	47

to understand by 29.9% of respondents and chosen as the least influential by 21.4%, suggesting that the Carbon Budget Method may be perceived as more influential than understandable.

Fig. 2 shows the results of respondent preferences with regard to ease of understanding and likelihood of influencing mode choice. For the purpose of comparison, both "hardest to understand" and "least likely to influence" are displayed as negative values on their respective graphs.

To assess the relationships between demographic variables, travel behaviour variables, and the respondents' assessment of the methods, a number of chi-squared cross tabulations were completed. Only cross-tabulations with frequency distributions significantly not random are discussed further.

Fig. 3 displays the variance in ease of understanding of methods with regard to gender. It is clear that while Methods 1 and 3 display increased levels of male selection and that Method 4 displays higher levels of female selection. Whether this reflects a male preference for more numerical presentation, as both the Basic Numerical and Carbon Budget Methods fall into this category and a female preference for more a visual presentation is unclear form this sample.

Fig. 4 outlines the results of the cross tabulation between the influence of methods and the age of the respondents. The graph indicates that influence of the Methods 1 and 4 increases in relation to the age of the respondents while the influence of Methods 2 and 3 decreases. If the latter are considered "contextual methods" insofar as they provide the respondents with

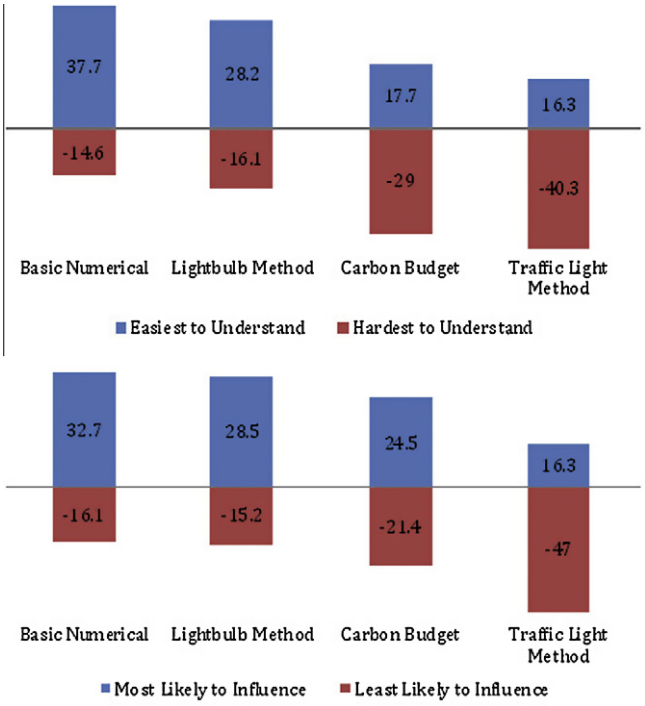

Fig. 2. Usefulness of method (top) and influence of method (bottom).

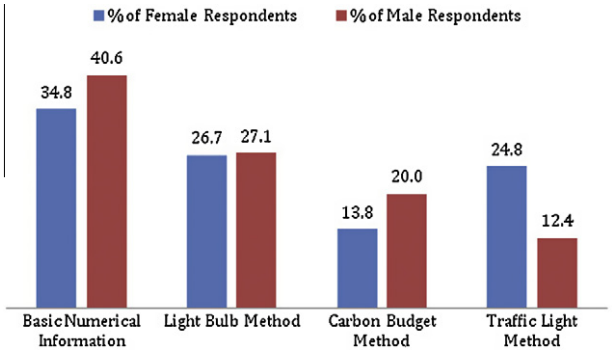

Fig. 3. Gender and easiest method to understand.

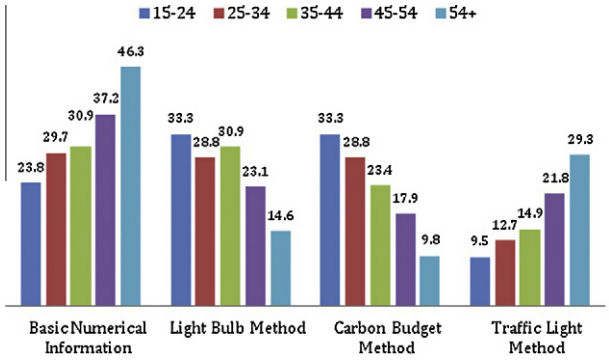

Fig. 4. Influence of method versus age.

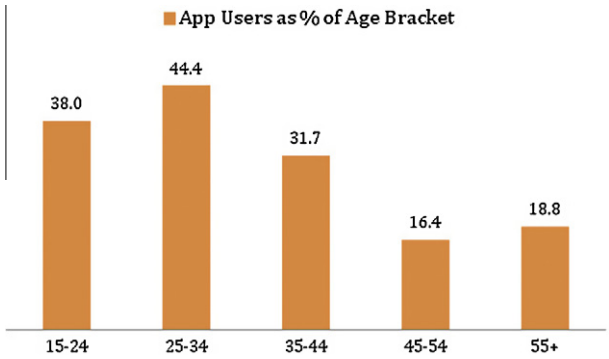

Fig. 5. Age of smart phone application user.

some context to allow them to relate to their emissions, it is evident that the influence of these contextualising methods decreases with respect to age and the influence of the two "non-contextual" methods increases.

The results indicate that various demographic groups favour different methods of presenting transport related carbon dioxide emissions. It is therefore important to consider the possibility that the likelihood that an individual would use a transport application or online journey planner may also be related to their demographic characteristics.

Fig. 5 displays the relationship between the age of respondents and their use of transport related smartphone applications within the survey sample. It is evident that a much greater proportion of younger people use smartphones to access transport and travel information. This can be partial accounted for as smartphone ownership was found to follow a similar distribution with respect to age within the sample. This would suggest that demand for contextual methods such as the Carbon Budget Method and Lightbulb Method would require extra consideration when designing a smartphone interface.

With respect to the use of these methods for internet based journey planners, however, the majority of all age brackets examined were found to these resources as a source of travel information therefore the overall results of the study are likely to apply.

4. Respondents comments

Respondents were able to provide feedback in the form of comments and suggestions about their impressions of the methods and on how they felt these methods could be improved; Table 2 offers some indication of what was said. It was hoped that these comments could provide a level of insight into the respondents' decision making process that was unavailable from the statistical analysis of method preference.

While the Basic Numerical Method was the most popular of the four examined, it also proved to be the least controversial with regard to the feedback that respondents provided.

The comments regarding the Lightbulb Method highlighted a number of issues such the association between lightbulbs and bright ideas and warmth. Another respondent questioned the idea of linking transport emissions with emissions resulting from a lightbulb as the public wouldn't be aware of the scale of either. While regard to the Carbon Budget Method, some respondents felt that the budget system was too prescriptive and guilt inducing, another respondent compared it to a game which could potentially be played with family members and friends to encourage emissions reduction. Comments regarding the Traffic Light Method tended to focus on the lack of quantitative data provided by the method and the false impression it was perceived to have created regarding the proximity of the emissions produced by the bus trip to those produced by

Table 2
Selected respondents; comments.

Basic Numerical Method
"*Having the numerical values was a much better option.*" – Female 15–24
"*Personally I would prefer method 1 or 2 – information provided factually. Method 3 &4 I would find too hectoring!*" – Female 45–54
Light Bulb Method
"*It's very interesting to see in comparison to lightbulbs/traffic lights as it totally put the points into perspective*" – Female 35–44
The number of lightbulbs idea is different from the others but seeing as most people would not be aware of energy or emissions linked with this, I do not see much point in including it. – Female 15–24
"*For the kg's of co2 or percentages to be effective the values must be of concern to the user, this is preaching to the converted! The light bulb (and its association with bright ideas) supports the worst polluter as the 'best idea'*" – Male 35–44
Carbon Budget Method
"*The budget will make people feel guilty and less likely to participate*" – Male 45–54
"*I don't think that the lightbulb or traffic light systems added much - the simple numerical value is easy to understand. The percentage of a daily carbon allowance is very striking but I would be concerned that for people who drive regularly they would be busting their limit so easily that they may feel that making small changes would have little impact on their total so may tune out.*" – Female 35–44
"*I liked the Daily Carbon Budget best because it's like a game and gets you motivated to aim for better results. If it was developed to accumulate the points over longer period of time (week/month/year), that'd provide even more motivation to do better. It could also become a reason to compare and/or compete between family members and friends!*" – Female 35–44
Traffic Light Method
"*I feel the traffic light system doesn't give a great impression of carbon emissions and the advantages of one system over another as it doesn't suggest how much of a difference between the options.*" – Male 15–24
"*Traffic lights suggest that the emissions of a bus journey (yellow light) are halfway between the car and the DART, whereas they are really much closer to the DART*". – Male 35–44

driving. This may be due to the simplistic nature of the graphical representation and would raise the possibility that a more detailed colour coded scale, such as the one used on white goods and building regulation in the EU, may be more effective.

5. Conclusions

This study examined the effectiveness of four methods of presenting transport related carbon emissions. Results indicate that there is a significant level of demand for all four methods used. While no method received preferential selection from the majority of respondents, presenting information on carbon emissions in a simple mass numerical form appears to be the method that is both the easiest to understand and the most likely to influence individual's behaviour. There is also a high level of support for methods that help respondents to put their emissions into context.

There is a very strong relationship between the ease with which the user can understand the method of communicating carbon emissions and the stated likely influence the method will have upon the respondent altering mode. Some significant variances in method preference were observed with regard to age and gender. Cross tabulations of respondent's mode choices with their method preferences produced insignificant results, suggesting that an individual's behaviour with regard to sustainable transport may not be related with their perception of carbon emissions.

Acknowledgement

This work was sponsored by the European Commission's PEACOX Project under the Seventh Framework Programme (FP7).

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