

Testing individuals' ability to compare emissions from public transport and driving trips

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ABSTRACT

In order to make informed environmental choices, individuals must first understand the potential environmental impacts of the modes of transport available, and be able to relate this information to their own internal reference points. This study examines the results of an on-line survey conducted to assess the ability of individuals in the Greater Dublin Area to estimate their potential carbon footprint for a variety of modes of transport. The results indicate that nearly one third of those surveyed stated that they simply did not know the carbon footprint of the modes in question, while those who provided emissions estimates showed a wide range of variance. Comparison with existing emissions factors indicate that respondents over estimate the environmental impact of bus journeys and under estimate the impact of small car and tram trips. The results of this study indicate the need for more specific emissions information to allow individuals to make informed and sustainable mode choices.

INTRODUCTION

Human economic activity is now recognised by the majority of scientists as a contributor to global climate change due to the emissions of greenhouse gases such as carbon dioxide (Bray, 2010). In the Republic of Ireland, transport emissions are estimated to have accounted for 19% of total emissions produced for the period 2008-2012 (EPA, 2012). While there is an apparent awareness amongst the population about the impact of their carbon emissions, there are also a number of barriers to the desired behaviour change, including lack of knowledge about the benefits of sustainable transport (Browne et al, 2011; Lorenzoni et al, 2007). If individuals are to be able to make decisions with the aim of reducing their transport related carbon footprint, they need to be sure that they are choosing the most sustainable alternatives available to them, such as public transport and non-motorised modes. While there are an ever increasing number of carbon footprint calculators available for a number of different technological platforms, offering comparisons between transport modes, it is still unclear to what extent these have educated the population with regard to carbon emissions, as these calculations are often far from consistent in terms of outputs (Kenny and Gray, 2009). This study seeks to examine the ability of the general public to assign values and implicit rankings to the carbon emissions associated with driving and a number of different public transport modes available in the Greater Dublin Area (GDA) as defined by the National Transport Authority (NTA).

PUBLIC TRANSPORT IN DUBLIN

The public transport system in Dublin is highly radial in nature and is centred upon the city centre and Central Business District (CBD). The rise in low density urban sprawl which accompanied the economic upturn labelled “the Celtic Tiger”, has resulted in a geo-spatial environment that is far from ideal in terms of the provision of public transport (Browne et al, 2011). Despite the construction of two new “Luas” tram lines and the upgrading of existing commuter rail services, large sections of the Greater Dublin Area remain accessible only by bus service. Existing bus networks are themselves highly radial, and service frequency levels vary widely across the network, leaving travellers certain areas of the GDA with little option but to drive (Caulfield, 2012). This is reflected in recent census figures (Central Statistics Office, 2012) which indicate that of the 529,812 residents Dublin making trips to work, 12.4% took Bus, Coach or Mini Bus and 7.5% took Train or Tram. In contrast 49.2% stated that they drove to work, and this figure rises to 55.5% when car passengers and commercial vehicles are accounted for. When compared to the Irish governments policy targets (DoT, 2009) of a 20% reduction in car commuter trips nationally and the majority of the commuter trips being undertaken using sustainable modes, it is clear that significant behaviour change is needed with regard to utilising existing public transport.

SURVEY METHODOLOGY

The research questions discussed in this paper formed part of wider study concerning carbon dioxide emissions and transport choices in the Greater Dublin Area. An online questionnaire (N=503) was distributed to a number of large public sector institutions, including municipal councils and government departments, in November and December 2012. Special attention was paid to ensure organisations outside the CBD were included to capture suburb commutes as these are likely to be very different from those anchored in the CBD. Table 1 outlines the demographic characteristics of the sample. Partly as a consequence of the distribution methods employed, the sample is over representative of younger individuals and those with higher levels of education. As this survey was

conducted online, some respondents failed to provide demographic information, however this was not deemed as an adequate reason to eliminate their estimates from the analysis.

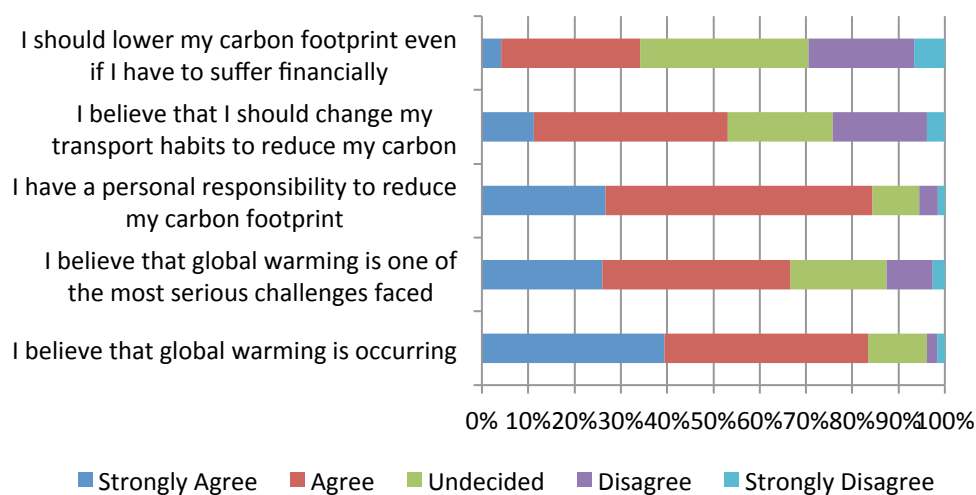
Table 1: Sample Properties

Gender	Male	Female	(No Answer)			
	42.8 (34.8)	57.2 (46.5)	18.7			
Age	15-24	25-34	35-44	45-54	55+	(No Answer)
	15.7 (12.3)	25.5 (20.1)	24.7 (19.5)	25 (19.7)	9.1 (7.2)	(21.3)
Education	High School	Diploma	Bachelors Degree	Higher Degree	(No Answer)	
	25.4 (20.5)	17.7 (14.3)	22.9 (18.5)	34 (27.4)	(19.3)	
Income	€0-24K	€25-49K	€50-74K	€75-99K	€100k +	(No Answer)
	22.2 (17.9)	44.6 (36)	20.9 (16.9)	6.4 (5.2)	2 (1.6)	(22.5)

ENVIRONMENTAL ATTITUDES

As part of this survey, respondents were asked to give their opinions on a number of statements regarding their existing attitudes towards climate change and transport. The results in Figure 1 show that the majority of respondents agree that climate change is occurring and is a serious issue, and they have a personal responsibility in this area.

Figure 1: Attitudes towards climate change



Access to Sustainable Transport

While it appears that there is concern and appreciation of the need to take action with regard to transport behaviour, there were also a number of barriers identified that prevent the necessary changes from occurring. The uneven geographical distribution of environmentally friendly alternatives alluded to previously, was reflected in the results of the respondents' perceived access to sustainable modes. Figures 2 and 3 indicate that perceived access to sustainable transport, for both work/educational trips and non work/educational trips, declines with respect to distance of the respondents' homes from the city centre. The issue of access to sustainable modes of transport becomes more acute as the length of commuting journeys increases with respect to distance from the city centre. As journey length is a major factor in terms of the production carbon dioxide emissions, the result of this is that individuals produce much higher emissions in rural areas (McNamara and Caulfield, 2011).

Figure 2: Access to Sustainable Transport vs. Residence (Commuting/Educational Trips)

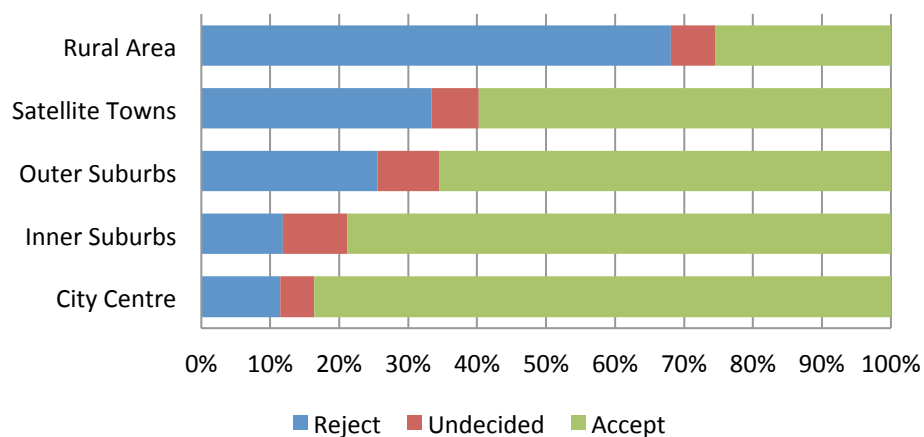
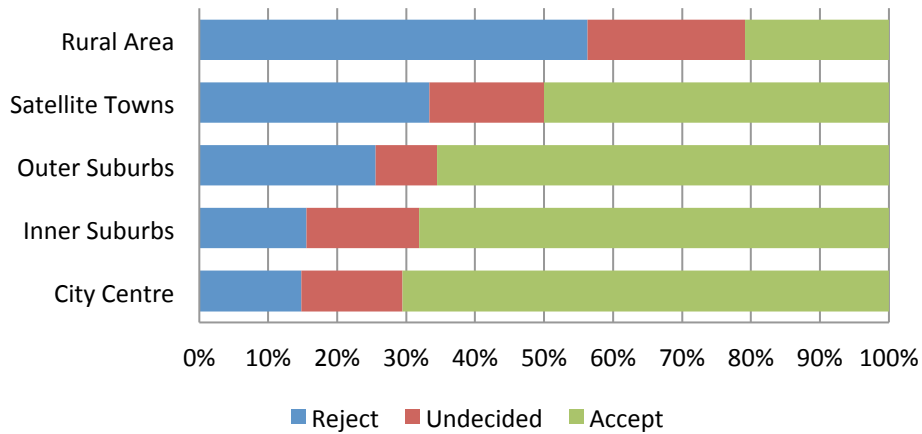


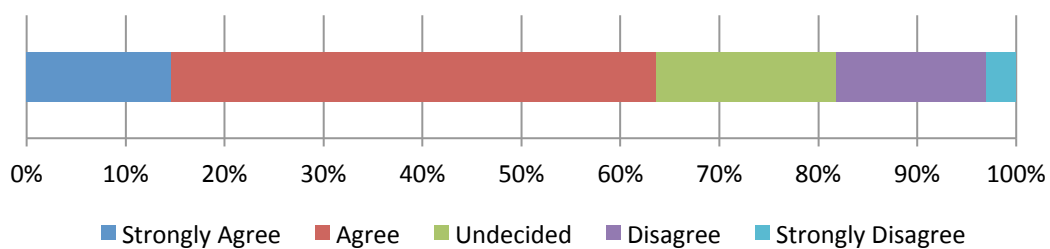
Figure 3: Access to Sustainable Transport vs. Residence (Non-Commuting/Educational Trips)



Informed Decisions

Among the questions posed to respondents was the statement “I have enough information to make informed transport choices”. The responses displayed in Figure 4 would indicate that the majority of respondents believe this to be true, with less than 20% disagreeing. However, due to concerns regarding the capacity of individuals to assess their own abilities highlighted in the literature (Whitmarsh et al, 2011; Lorenzoni et al, 2007), and issues such as self report bias and social desirability bias, it was decided to test this assertion further.

Figure 4: “I have enough information to make informed transport choices”



TESTING EMISSIONS KNOWLEDGE

While respondents may have been of the opinion that they are able to make informed choices with regard to sustainable transport options, this would appear to contradict findings from the literature (Whitmarsh et al, 2011; Gadema and Oglethorpe, 2011). Carbon dioxide emissions have a number of specific features that make them harder to relate to than other aerosol pollutants. Carbon dioxide is both colourless and odourless, and emissions may be produced at a distance, both in terms in time and space, from the individual who benefits from the related economic activity. A prime example in public transport is the tram system in Dublin. The tram itself does not produce any emissions directly as it is powered electrically. However, due to its operation a large amount of electricity energy must be used, the majority of which is produced from fossil fuels (Howley, 2009). To test this hypothesis, respondents were asked to estimate how much CO₂ six different modes would emit for a 10km journey. The six modes considered for this experiment were:

- Small Car (defined as less than 1.6L)
- Large Car (defined as 1.6L+)
- Tram(A light rail system operating in the Greater Dublin Area)
- Heavy Rail (A DART/Suburban Rail system operating in the Greater Dublin Area)
- SUV (Sports Utility Vehicle)
- Bus

These modes represented the majority of trips undertaken in the GDA (Central Statistics Office, 2012). The decision to provide respondents with three driving options was due to the large proportion of trips accounted for by this mode (Gormley, 2011). It is also important to consider that there are individuals who do not have access to sustainable modes of transport and therefore car may be their only option, with respect to emissions reduction, is to switch to car models with lower emissions ratings. Electric vehicles were omitted as they are still uncommon in Dublin, and the

RESULTS

Emissions Estimates

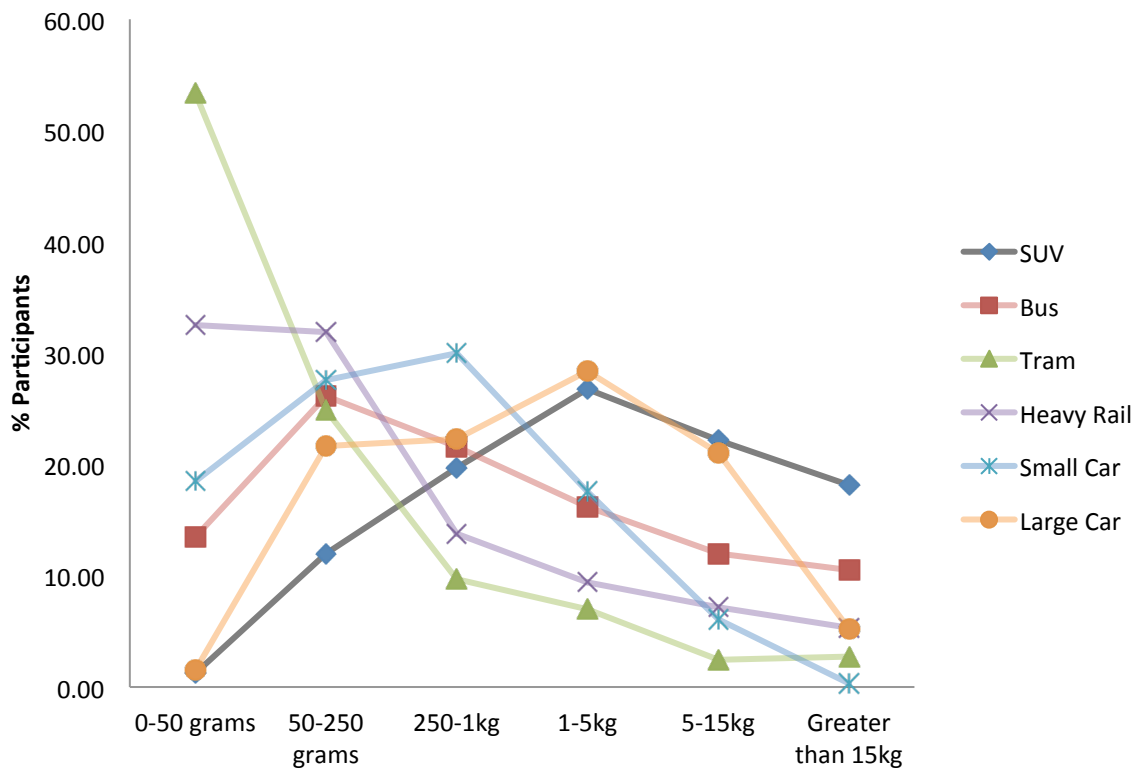
Table 2 displays the percentage of respondents who simply stated that they didn't know the emissions associated with each mode. This represents roughly a third of overall respondents. This finding in itself indicates that a sizeable proportion of the population are simply unable to provide any type of estimate, or even guess, regarding their transport emissions. As the question was presented in the first section of the survey we can discount the influence of survey fatigue. For the rest of the paper, analysis is performed on only the respondents that provided emissions estimates who will henceforth be known as "participants". It was found that the vast majority of individuals who stated that they did not know for any given mode also failed to provide estimates for any of the other modes. Therefore it was decided to consider all emissions estimates provided, for the purpose of further analysis.

Table 2 "Don't Know"

	Small Car	Large Car	SUV	Bus	Tram	Heavy Rail
Don't Know	32%	32.6%	32.6%	32%	32.4%	33.5%

Figure 6 displays the distribution of the participants' emissions selections for each of the modes under consideration. It is clear that participants, on average, assign higher emissions values to Large Cars and SUV than to public transport modes such as Bus and Heavy Rail (DART). It is also clear that the Tram option is the mode associated with the lowest emissions estimates.

Figure 6: % Participants vs. Emissions Estimates

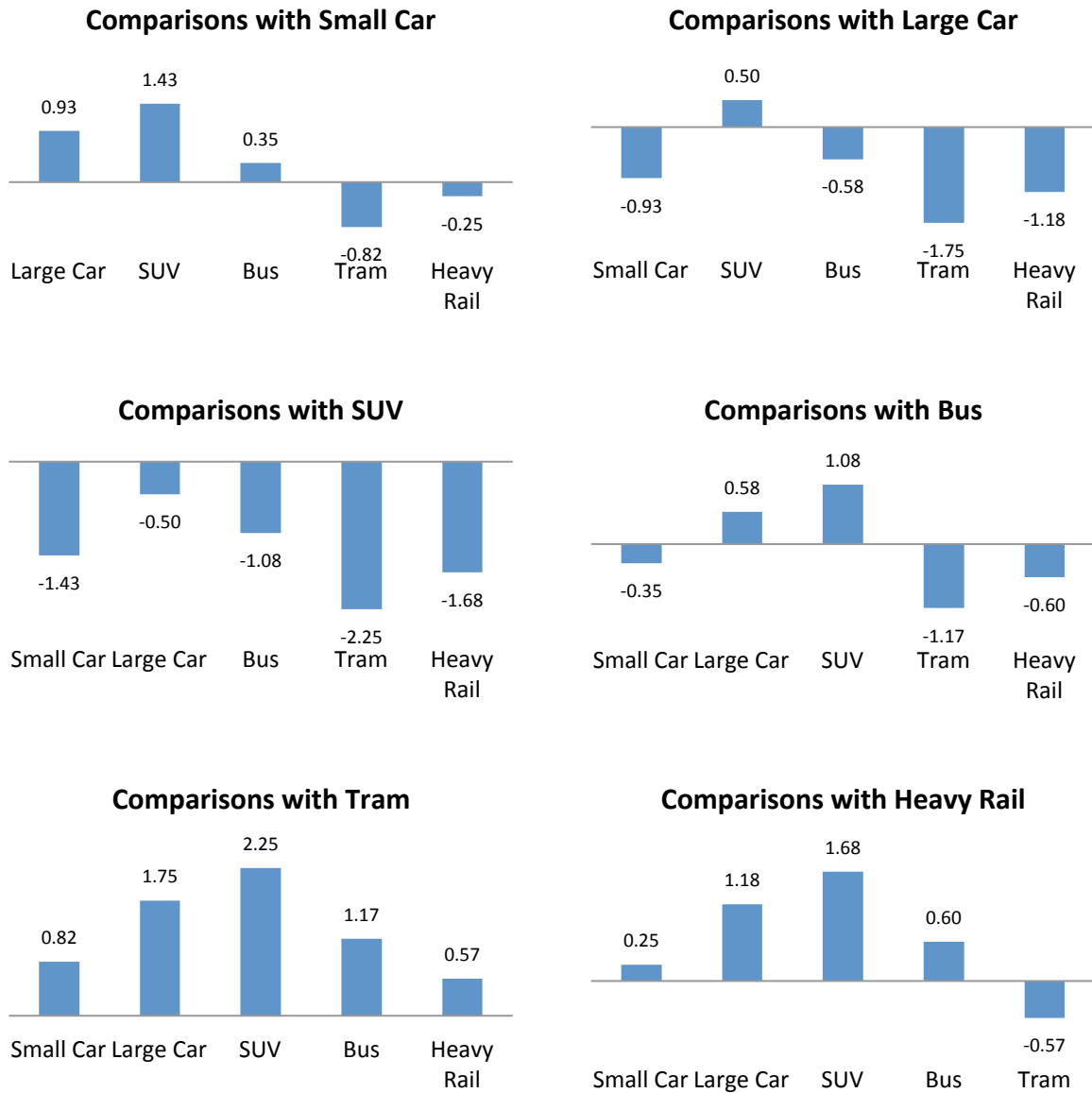


Whereas Figure 6 presents the aggregate absolute category selection of respondents, it is also important consider the perceived relative position of modes in terms of associated carbon emissions. When an individual is faced with a decision between modes based upon their environmental impact, it may not be important that he/she are aware of the absolute emissions related to each mode, rather that they are able to recognise the differences in scale between the emissions associated by the available options. Acknowledging the need to assess relative emissions placement, Figure 7 presents the results of emissions comparisons between modes. Using the ordinal values assigned to categories in Table 3, it is possible to assess the aggregate “distance” between emissions estimates. For example if an individual placed Small Car emissions in Category 4 and SUV emissions in Category 6 the distance between these estimates is said to be +2. For results presented in Figure 7 positive values relate to higher estimates and negative values to lower relative estimates. For example it can be observed that aggregate estimates place SUV higher and Tram lower than all other modes, and that the Bus option is observed to have higher associated emissions relative to the Small Car option.

Table 33: Assignment of Ordinal Values

Category	0-50g	50-250g	250g-1kg	1-5kg	5-15kg	>15 kg
Ordinal Value	1	2	3	4	5	6

Figure 7: Mode Comparisons



As the emissions estimates were bound by the need to acknowledge real world conditions, where modes have emissions ranges rather than definitive values, and where it is possible that these ranges overlap, the respondent selections cannot be treated as ranked data. Within the sample 161

distinct relative emissions ordering patterns were observed, with none occurring more than 20 times. Further analysis of mode ranking, with respect to emissions factors, is presented in the next section

Accuracy of Estimates

It was deemed important to provide a comparison with the participants' estimates and current emissions estimates for the Greater Dublin Area. Using the emissions values put forward by Walsh et al, (2008) concerning carbon emissions produced by transport modes in Ireland, it is possible to conduct a comparison between the participants' estimates and existing emissions factors. Values for the categories Small Car and Large Car are taken as falling between 1-5kg. Walsh et al (2008) gives a value of 0.120 per passenger for general cars in "normal" conditions. The United Kingdom's Transport Direct website (Transport Direct, accessed 2013) carbon calculator gives a small car value of 1.3kg for a 10km journey while Transport for Scotland (Traffic Scotland, accessed 2013) gives a value of 1.7kg for a petrol car with an engine capacity of below 1.4 litres, so we can assume that both car categories are likely to fall within the 1-5kg range. Table 5 indicates the categories into which each respective mode is most likely to fall, and based upon this, how accurate the participants' estimates were. To account for variances in per passenger carbon emissions with regard to vehicle occupancy, the results were presented for modes at both average and full occupancy. Results assuming average vehicle occupancy are displayed in Table 4, while Table 5 presents the results associated with maximum occupancy. The adjusted results displayed in Table 6 represent a summation of the correct selections from the two categories and takes into account the respondents who stated that they were unable to assign values to the modes.

For most modes participants displayed an accuracy rate of 45-50 %, which when adjusted for all respondents corresponds to a 30-35% rate. The most striking result appears to be with regard to the accuracy of Tram estimates, with only than ten per cent of participants correctly estimating its associated emissions, even when both occupancy levels are assumed.

Table 4: Assuming Average Emissions Values

	Small Car (Av)	Large Car (Av)	SUV (Av)	Bus (Av)	Luas (Av)	DART (Av)
Emissions	1.2 kg	1.5 kg	1.8kg	0.35kg	0.8 kg	0.29kg
Category	1-5kg	1-5kg	1-5kg	250-1kg	250-1kg	250-1kg
% Correct	17.1%	31.1%	27.1%	21.9%	10.3%	15.1%

Table 5: Assuming Maximum Occupancy Emissions

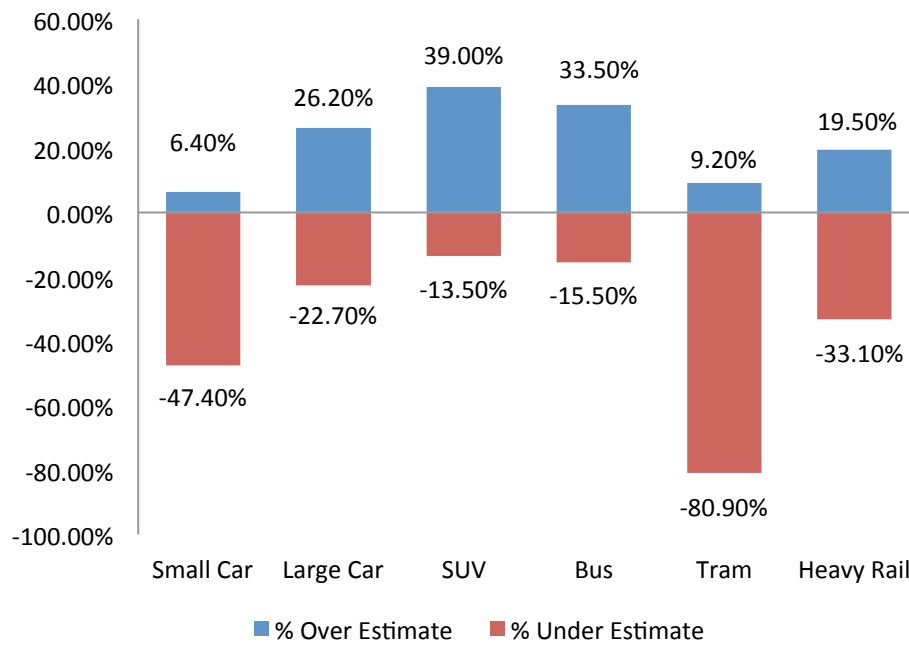
	Small Car (Max)	Large Car (Max)	SUV (Max)	Bus (Max)	Luas (Max)	DART (Max)
Emissions	~0.4kg	~0.5 kg	0.68	0.16	0.64	0.11
Category	250-1kg	250-1kg	250-1kg	50-250kg	250-1kg	50-250g
% Correct	29.9%	19.3%	20%	29.1%	10%	32.3%

Table 6: Adjusted Accuracy

	Small Car	Large Car	SUV	Bus	Luas	DART
Sum	47%	50.4%	47.1%	50%	10%	47.4%
Adj.	32%	33.4	31.7%	34%	6.8%	31.5

Treating both average and maximum occupancy values as correct it is possible to categorise the remaining selections as either under or over estimates. Results displayed in Figure 7 clearly indicate that a large participants under estimated emissions for both Small Car and Heavy Rail. However, the most striking result is that 81% of participants under estimated the emissions associated with the Tram option.

Figure 8: Under and Over Estimation of Emissions



In both the case of assuming average or maximum occupancy, a number of logical relationships emerge, such as all public transport modes having lower emissions than driving modes or all driving modes falling into the same category. The results in Table 7 indicate the percentage of participants that correctly identified the emissions relationships between modes. Perhaps the most striking result is that only 34.6 % of participants correctly stated that all driving modes produce higher emissions than all public transport modes. This can be considered somewhat worrying from a public transport perspective as it appears that individuals may not be aware of the potential emissions reductions associated with switching from driving.

Table 7: Comparisons

SUV=Large Car	SUV=Small Car	SUV>Tram	SUV>Bus	SUV>Heavy Rail	Large Car=Small Car
110	26	226	163	197	46
43.8%	10.3%	90%	65%	78.5%	18.3%
Large Car>Tram	Large Car>Bus	Large Car>Heavy Rail	Small Car>Tram	Small Car > Bus	Small Car > Heavy Rail
214	147	186	165	94	128
85.2%	58.5%	74.1%	65.7%%	37.4%	50.9%
Bus= Tram	Bus> Heavy Rail	Tram > Heavy Rail	All Cars Equal	All Cars>All PT	All Correct
73	123	12	20	87	0
29%	49%	4.8%	7.9%	34.6%	0%

CONCLUSIONS AND DISCUSSION

The results of the attitudinal statements contained in this research, presented in Figure 1, indicate that there is widespread recognition that climate change is a serious problem and that individuals acknowledge that they have personal responsibility with regard to tackling this issue. There are a number of barriers in terms of changing transport behaviour including perceived lack of access to sustainable modes with respect to residential location. While public transport offers a realistic sustainable alternative to a considerable proportion of the population, this is tempered by the inability of respondents to make accurate estimates concerning the impact of their transport choices.

The results of the examination of emissions knowledge indicate that a minority of the population have a good knowledge of the carbon dioxide emissions associated with different modes of transport. Roughly one third of those surveyed stated that they simply did not know the levels of emissions for each mode. This is in contrast to the stated ability of respondents to make informed

transport choices. This indicates that not only are individuals unable to make accurate comparisons between available modes, they are also overly confident of their own abilities.

For those respondents who did answer, the overall carbon footprint of public transport modes was estimated to be less than driving. Tram and Heavy rail were estimated to produce fewer emissions than any driving categories; however bus journeys were viewed as falling with the same categories as driving.

The environmental impact of small cars was under estimated suggesting that individuals may be of opinion that switching to a smaller car may be an effective method of reducing their carbon footprint, whereas substantial reductions can only occur via mode change. The environmental impact of the tram system was also greatly under estimated, while the carbon emissions attributed to buses were over estimated. One potential explanation for this is that the tram system is relatively new and has no visible emissions, whereas buses produce visible emissions that may be confused with greenhouse gases. It may also be the case that respondents were unable to understand the idea of per passenger emissions rather than total vehicular emissions. However, this would also be of concern with regard to taking personal responsibility for transport emissions as individuals should be able to acknowledge their own personal contributions to climate change.

If individuals are to be asked to make sustainable personal transport choices they must have the ability to make accurate comparisons with regard to the environmental impact of the modes available to them. In general public transport modes were viewed as more sustainable than driving, with the exception of bus journeys. The over estimation of carbon emissions associated with bus journeys may result in individuals overlooking this mode as a sustainable alternative. This may be considered as an important research outcome as individuals appear to be over estimating the environmental impact of the largest and most extensive public transport option in the Greater Dublin Area (Central Statistics Office, 2012). The results of this study highlight that there is a need to provide better levels of education and information to transport users with regard to the

environmental impacts of the alternatives available to them, in particular with regard to the city's bus network.

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