AN EXAMINATION OF THE ROLE OF EMISSIONS INFORMATION IN TRANSPORT BEHAVIOUR: THE RESULTS OF A SMART PHONE TRIAL IN DUBLIN, IRELAND

William Brazil
Department of Civil, Structural and Environmental Engineering
Trinity College Dublin, Ireland
Email: wbrazil@tcd.ie
Tel: +353 1 896 3199

Brian Caulfield*
Department of Civil, Structural and Environmental Engineering
Trinity College Dublin, Ireland
Email: brian.caulfield@tcd.ie
Tel: +353 1 896 2534

Efthimios Bothos
Institute of Information and Computer and Communication Systems
The National and Technical University of Athens,
Athens, Greece
Email: mpthim@mail.ntua.gr

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* Corresponding Author

ABSTRACT
Within the transportation sector there is an emerging trend towards providing individuals with more information regarding the choices available to them. There are an increasing number of smartphone applications and online journey planners designed to provide carbon dioxide emissions information to users, in conjunction with their primary journey planning functionality related to time and cost. Such information may be either a policy instrument to promote behaviour change, or an additional feature to enhance an existing journey planners' appeal, however in either case little empirical research currently exists with regard to the effectiveness of such approaches. This paper outlines the results of a project undertaken to design and test a smartphone application with the purposes of better communicating trip specific environmental information to users. This paper also provides details of the testing application via a field trial conducted in Dublin. The results arising from this trial demonstrate that while the participants displayed interest in the emissions information that they were provided with, and the application was found to have a positive educational impact, the emissions information provided was not enough to produce significant behaviour change during the trial period. These results would suggest that while the provision of emissions information via digital technology platforms may play an important role in terms of increasing public knowledge and visibility of emissions, it cannot be, in isolation at least, considered to be a primary driver of behaviour change.

INTRODUCTION

Transport activities account for roughly one fifth of global anthropogenic carbon dioxide emissions (*1*). A large proportion of these emissions arise as a result of the transport choices that ordinary individuals make. By choosing to drive rather than to take public transport or non-motorised modes such as walking or cycling, an individual can make a decision that contributes to the destabilisation of the global climatic commons. Conversely, by choosing to travel in more sustainable manners, individuals have the opportunity to help mitigate the effects of climate change. One barrier to promoting such behaviour change in the personal transport sector is the lack of accurate information to allow individuals to make decisions in line with their beliefs and values (*2*). Whereas in previous decades it has been difficult for individuals to receive information relating to the extent of their own emissions contributions, digital technologies now present new opportunities to those hoping to promote transitions to more sustainable transport practices via information provision. In light of these developments there is a need to understand the role of emissions information in terms of both increasing users' knowledge of environmental impacts, and also altering transport behaviours.

Smartphones and Transport Information

Advancements in intelligent transport systems as well as Information and communications technology (ICT), particularly smartphone technology, have enabled individuals to access more transport information than ever before. Smartphone users are now able to access information such as real time public transport data, journey planning services, and information relating to current traffic conditions. Applications such as Google Maps and Apple Maps are highly popular (*3*) and provide users with large amounts of up to date information to help them make more informed transport choices (*4*).

Within the Irish context alone there is a large degree of variety of services offered by respective applications. Journey planners such as the Transport for Ireland National Journey Planner (*5*) and Hit-The-Road (*6*) provide individuals with the ability to plan trips across a number of modes, while mode specific applications such as the Dublin Bus app (*7*) and Luas Times (*8*) provide information about individual modes, and services such as Google Maps (*9*) have now integrated both transit and real time traffic capabilities to allow for multiple functionalities.

When examining the role of transport information Lyons (*10*) argues that the provision of information has three functions: "1. make the individual aware of the travel options available to them for a particular journey; 2. Empower the individual to make more fully informed travel choices; and 3. Assist the individual in being able to successfully undertake and complete the journey". Specifically, concerning digital technologies, Chorus et al (*11*) has highlighted the role that such information services can play as a means of attracting new customers to a transport service or retaining existing ones. Similarly Watkins outlines the utility that Advanced Traveller Informaiton System (ATIS) provides to the user as "One inexpensive way to combat the perception of unreliability from the user perspective is real-time transit information" (*12*).

Environmentally Themed Applications

Smartphone applications are increasingly being used to highlight "non-salient" (*13*) issues associated with transport, such as the health benefits and environmental impacts associated with certain modes and routes. From the perspective of climate change mitigation these services represent a previously unavailable opportunity to raise awareness of the carbon dioxide emissions arising from individuals mode choices. While the transport sector produces a significant proportion of anthropogenic greenhouse gases, research indicates that there is a considerable amount of confusion amongst the general public regarding the emissions associated with various modes of transport available to them (*14*). The journey planning applications now available across smartphone platforms have the ability to present such information in a trip specific and tailored manner that has been identified as a requirement to making such information more accessible (*2*). Whereas previous information provision campaigns have been limited by a need to use national average statistics and less precise information, smartphone applications can both provide very accurate emissions calculations specific to the alternatives available to the user, while also creating a historic record of their choices, and hence their resulting emissions records.

The emergence of such data dissemination services indicates a willingness to help individuals make more informed transport choices. The design and implementation of such services places resource demands upon the relevant organisations, however little research has been carried out regarding their effectiveness as instruments of behaviour change, and hence the effectiveness of such investments. While previous studies using stated preference methods would appear to indicate the emissions information could play a role in promoting use of public transport (*15*), there is very little empirical research (*16*), with regard to the impact of such information via smartphone applications in a real world setting. To investigate if information supplied via smartphone applications has the ability to significantly reduce individuals transport emissions, a field trial was run in Dublin in the late summer and autumn of 2014. This trial utilised a purpose built environmentally themed journey planning smartphone application called PEACOX (*17*). The details of PEACOX application and associated project are outlined in the next section.

THE PEACOX APPLICATION

The smartphone application developed as part of the PEACOX project (*17*) was designed with the aim of developing a mobile platform to provide users with previously unavailable information regarding the environmental impact of their personal transport choices. Specifically, the application was designed to enable users to receive an estimate of the carbon dioxide emissions associated with the transport routes available to them, and to allow them to make comparisons between modes and routes based on this information.

The application was designed to operate as a fully functional journey planner; with the additional ability to alert users to the carbon dioxide emissions associated with their transport choices. By designing an application with strong primary functionality, it was hoped that the application could persuade individuals to reduce their transport related carbon dioxide emissions, while at the same time providing them with information to make it easier for them to undertake their journeys. The need for functionality other than solely the provision of emissions information was confirmed by earlier research undertaken as part of the project. This research identified that, while users may be in need of environmental information from an educational standpoint (*18*), the provision of this information in isolation is not likely to be enough to promote use of such an application (*15*). Therefore the journey planning functionality was included in order to provide users with a greater impetus to access the application and allow it to compete with other similar services.

System Design and Data Flow

The PEACOX system comprises an application developed for Android based smartphones and a set of server side components incorporating the business logic. The Google Maps directions application programming interface (API) (*9*) is utilized to retrieve a set of routes to reach a destination. This choice enabled the application to ensure the user received the best possible routes in terms of accuracy and reliability. Figure 1 outlines the system design and the flow of information between the user, the application, and the Google Maps API.

When accessing the application the user inputs a desired origin and destination and the application sends a route request to the server side components for further processing. With the use of the Google Directions API, the server retrieves a list of routes with different modalities over the Hypertext Transfer Protocol (HTTP) / Representational State Transfer (REST) protocol. The routes are then passed to the bespoke PEACOX emissions model (*17*) to allow for the generation of CO_2 emissions estimates. In order to ensure the fast response times required for an application of this nature, a set of emission factors were derived for each mode of transportation which are utilized to calculate estimates of the total emissions per route as shown in Equation 1.

$$TotalRouteEmissions = \sum_i Segment_i Distance * \text{Modality}_i Factor \quad (1)$$

Where: $Segment_i$, *Distance* is the distance of the ith segment and Modality_i Factor is the emissions factor associated with the modality of the segment.

Once the emissions estimates are produced, the routes are filtered and ordered. The filtering function operates with a set of rules that remove routes which are not usable based on simple heuristics, i.e. routes with too many changes of modalities (over 4) and routes with very long duration compared to the shorter one (over 60%). The ordering function groups routes according to the main modality type (which can be one of "car", "public transportation", "walk", "bicycle") and ranks them according to the emissions produced. In the case of the PEACOX application, options were ordered in terms of their associated emissions, meaning that non-motorised or public transport options took prominence at the top of the list of available alternatives. The route results were logged in a database for further processing. All server side components were implemented with the Java Spring framework (*19*).

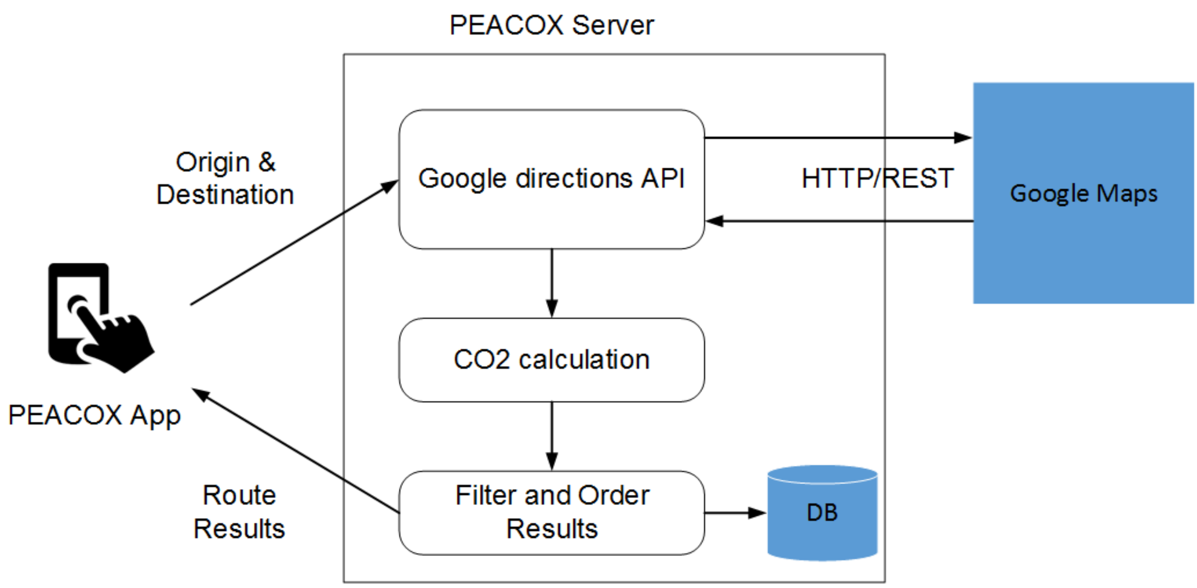

FIGURE 1: PEACOX SYSTEM DESIGN AND DATA FLOW

User Interaction

When users opened the application they were asked to input a desired origin and destination. Moreover, they could set their preferences by selecting among the following options: comfortable (i.e. with short walking paths and few mode changes), barrier-free (i.e. to avoid stairs or escalators) or fast trip (short) routes (Figure 2 part 1). The default option was to fetch all possible routes. Based upon these inputs the application returned a number of potential routes and modes, along with information regarding the trip time and carbon dioxide emissions associated with each alternative (Figure 2 part 2). When users selected a given option they were presented with additional information, specifically a visual map representation of the route and their current location (Figure 2 part 3). At this point users were asked to select whether they had taken the trip or intended to take the trip (Figure 2 part 4). Due to this additional functionality the application was able to operate as a trip logger, recording both the selected option(s) and the associated carbon dioxide emissions for each of the trips undertaken by the users.

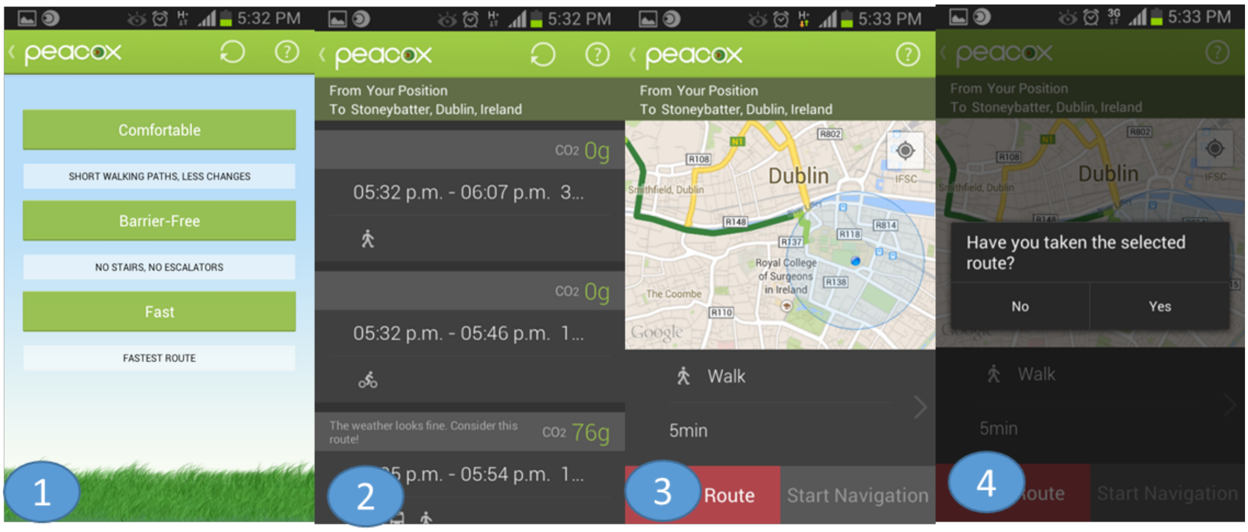

Figure 2: PEACOX Interface

METHODOLOGY

In late summer and autumn of 2014 a seven-week field trial was undertaken in Dublin to investigate the impact of emissions upon the travel choices of application users. The format of the trial involved two distinct stages:

- Stage 1: Pre-trial workshops and controlled testing
- Stage 2: An application usage period and a post-trial debriefing workshop

The first stage of the testing comprised of a number of pre-trial workshops that were designed to both familiarise users with the application and to give them a supported forum to learn how to use it effectively. As part of these workshops an experiment was carried out using the application to gain a better understanding of how participants were likely to interact with the information that it provided them with. The workshops also allowed for the collection of data about users' current knowledge, understanding, and concern regarding the environmental impact of their transport choices.

The second section of the trail involved the participants using the application for a seven-week period to plan some of their day-to-day trips and record them using the application. Users were not asked to log all of their trips during the trial period, as it was felt that this would put an undue burden upon them, however, they were asked to try and use the application as naturally as possible. Following the completion of this period post-trial workshops were undertaken to collect information regarding users' experiences with the application, their thoughts on the role of emissions information on their behaviour over the previous weeks, and any changes or recommendations that they may wish to provide with respect to the application or the information provision approach.

It was hoped that the combination of a more controlled experiment (pre-trial workshops) and in-field testing would provide a comprehensive and holistic understanding of the potential role of trip specific emissions information on individuals' knowledge and behaviours.

Sample

Twenty-one individuals were recruited to take part in the application trial. As participants were recruited mainly from within the staff and students of the University, the sample overrepresented younger individuals. Therefore, the results of this study cannot claim to represent the attitudes and behaviours of the general public, however as there is little research regarding the demographic characteristics of potential users of such applications, it is unclear as to what characteristics would define such a population. Therefore, while this does provide a limit to the ability to generalise these results, this study does represent a first attempt (to the knowledge of the authors) to examine the impact of emissions information on transport behaviour. While a larger sample size would have been preferable, this was limited due to the resource restrictions imposed by the in-depth nature of the study.

PRE-TRIAL WORKSHOPS AND INFORMATION ASSESSMENT TESTING

Before the commencement of the in-field testing, a number of introductory workshops were conducted before the participants started actively using the application. During one of the workshop participants were asked to access the application for a number of hypothetical trips. These trips were designed to examine how users assessed the information (both trip time and associated emissions) that they were presented with by the application interface. Once presented with the options by the application users were then asked to state which option they would choose. In addition users were asked to state how they made their choices, as it was deemed important to assess whether the emissions information was being considered, and if so was it a priority. When considering these trips users were asked to undertake a questionnaire stating, that for each of the trips, had they:

- Only looked at trip time
- First looked at trip time and then emissions
- First looked at emissions and then trip time
- Only looked at emissions

Overall there were twenty scenarios for the participants to consider. Participants were asked to input their own specific locations into the application, such as their home or place of work, so that while the trip types are comparable, the origin and destination pairs were not identical rather they were unique for each user. These trips varied in terms of location, trip distance, weather conditions, and the stated availability of a car. Table 1 outlines the scenarios that participants were asked to consider. The "unknown" origin and destinations were defined by the workshop co-ordinator, rather that the by the user, as would be the case with the Home or Work options. These unknown origins and destinations were included to ensure that users were actually gaining information from the application rather than merely choosing options that they may regularly use are that they may be aware of.

TABLE 1: HYPOTHETICAL TRIPS

Scenario	Description	Restrictions
1	Home to Work	No Restrictions
2	Work to Home	No Restrictions
3	Home to Work	No Car Available
4	Work to Home	No Car Available
5	Home to Work	Bad Weather
6	Work to Home	Bad Weather
7	Home to Shopping	No Restrictions
8	Home to Friend's House	No Restrictions
9	Home to Friend's House	No Car Available
10	Home to Sports Arena (Aviva)	No Restrictions
11	Home to Social Event (Restaurant/City Centre)	No Restrictions
12	Unknown to Unknown (<2km)	No Restrictions
13	Unknown to Unknown (<2km)	No Car
14	Unknown to Unknown (<2km)	Bad Weather
15	Unknown to Unknown (<5km)	No Restrictions
16	Unknown to Unknown (<5km)	No Car
17	Unknown to Unknown (<5km)	Bad Weather
18	Unknown to Unknown (<10km)	No Restrictions
19	Unknown to Unknown (<10km)	No Car
20	Unknown to Unknown (<10km)	Bad Weather

Information Assessment Results

The results of the overall analysis of users' assessment of the time and emissions information provided by the application are presented in Table 2. These results represent the stated role of both of trip attributes (travel time and emissions) in the participants' decision-making processes. The results indicate that emissions are very much the attribute of secondary importance to users, compared with the travel time associated with the trip. In 46.8% of all trips the users stated that they did not even consider emissions information provided to them by the application when assessing the routes and modes available to them. Even when emissions are considered, they are only of primary interest in 7.2% of cases. While the dominant role of travel time cannot be considered to be a surprising finding, the failure of users to even consider emissions information for nearly half of all trips must be seen as concerning with regards to the ability the information provided to influence behaviour.

The implication this finding must be considered to be a major limitation of information provision, in terms promoting sustainable transport, as if users are not even taking in the emissions information they are presented within a controlled experimental setting, this information cannot be expected to play a role in their decisions in real world scenarios. A full breakdown of the information assessment for each of the trips under consideration is provided in Table iii in the appendix.

TABLE 2: INFORMATION ASSESSMENT AVERAGES

Information Assessment	Workshops
Only Travel Time	46.8%
Only Emissions	6.0%
First Time, then Emissions	46.0%
First Emissions, then Time	1.2%

Within the trip set presented to users it was possible to categorise the various scenarios based upon common shared characteristics. Table 3 shows a comparison between trips where participants were asked to imagine that bad weather was present, and trips where weather conditions were not mentioned. The values presented in Table 3 represent users' responses that stated they only looked at travel time, and therefore did not consider associated emissions in any what. It is clear that in all cases where comparisons can be made, that bad weather appears to induce a greater tendency to focus solely on travel time. Table 3 also presents the results of an analysis of the trips where conditions were held constant with the exception of participants being told that a car was available for the trip. The results indicate the percentage of users who stated that they did not consider emissions in any before making their mode choice. With the exception of the 2km trip, it is clear that the lack of a car in the choice set makes users more likely to consider the emissions associated with the modes available.

TABLE 3: INFORMATION ASSESSMENT AND JOURNEY LENGTH (ONLY LOOKED AT TRAVEL TIME)

	No Restrictions	Bad Weather	Difference
Home to Work	51.4%	64.9%	13.5%
Work to Home	44.4%	52.8%	8.8%
2km Trip	35.1%	48.6%	13.5%
5km Trip	48.6%	56.8%	8.8%
>10km Trip	48.6%	54.1%	5.5%
	No Restrictions	No Car	Difference
Home to Work	51.4%	40.5%	-10.9%
Work to Home	44.4%	40.5%	-3.9%
2km Trip	35.1%	35.1%	0
5km Trip	48.6%	43.2%	-5.4%
>10km Trip	48.6%	37.8%	-10.6%

Overall it would appear to be clear from this section of the study that emissions information is very much of secondary importance in comparison to trip travel time when individuals are making their route and mode selections.

APPLICATION FIELD TESTING

The second section of the testing relates to the in-field testing of the application by participants as part of their daily lives. This section of the trial involved the users being asked to access the application to plan trips they were taking, and in turn they would be provided with feedback regarding the environmental impacts of both the trips they had taken and the alternatives that were available to them. It must be noted that users were asked to access the application more frequently than may be the case in a more natural setting, due to the need to collect an adequate number of observations during the limited trial period, however there was not a requirement upon them to use the application for every trip they undertook as it was felt that this would place an excessive burden on them. One consequence of this approach was the large variation in application usage across the sample. The resulting application usage rates vary widely between different trial participants with overall searches ranging from only 4 for the entire trial period to the 115, with an average of 31.9 searches being made and standard deviation of 32.9 trips. An outline of the searches and trips taken by each user is presented in Table i in the appendix. While such behaviour may result in less data for analysis, lack of application use in and of itself makes it clear that a significant proportion of users derived little or no utility from the application, and therefore providing information via such a platform is clearly not an effective means of reaching all members of the community.

Figure 3 presents the per week trips searched and taken using the application during the trial period. It is clear that after an initial period of high usage in the first three weeks, the number of searches performed using the application diminishes sharply as time passes. This may be explained due to the novelty factor of using the application wearing off, or it may be due to users having already gained the information they needed and no longer have an incentive to access the application. When it is considered that this data was collected from a trial where users were actively encouraged to access the application, it highlights the difficulty in using journey planning applications as a platform to repeatedly reach out to individuals regarding the environmental impact of their transport choices.

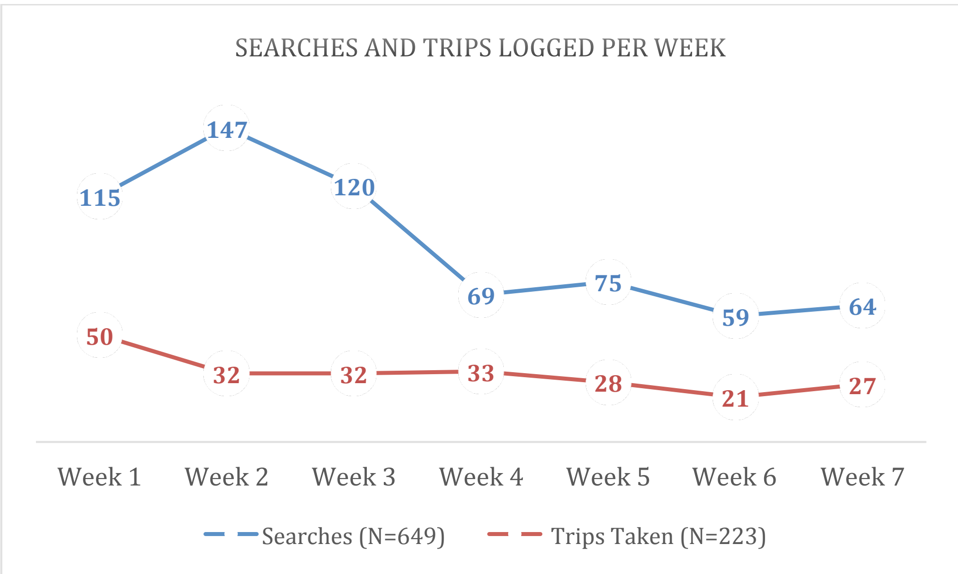

FIGURE 3: SEARCHES AND TRIPS LOGGED PER WEEK

The integrated logging functionality enabled the application to record the carbon dioxide emissions related to the trips that the users stated they had taken as part of the trial. These emissions were calculated using a simple factor based model and therefore cannot be considered to be true emissions, however they do represent the figures presented to the users, and which they would have based their decisions upon if they considered the emissions information. Therefore, for the sake of this analysis these figures are used to estimate weekly emissions. Figure 4 outlines the carbon dioxide emissions in grams produced by users and recorded by the application during the period of the trial. These values represent the average per-trip emissions for all users for each of the relevant trial weeks. It can observed that there is a downward trend in recorded emissions for the first four weeks of the trial followed by a sharp in increase in the latter half of the study.

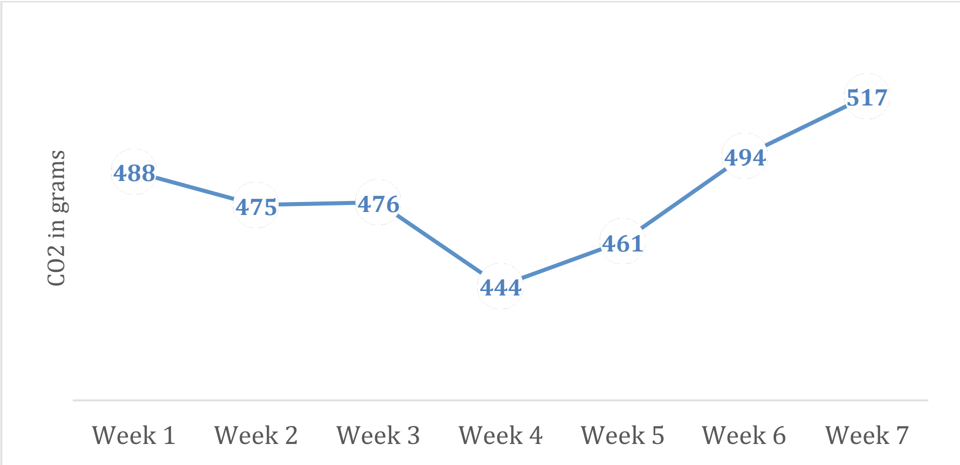

FIGURE 4: EMISSIONS LOGGED PER WEEK

Table ii in the appendix provides an outline of the per trip emissions for each of the individuals who had taken part in the field trials. These results show a large degree of variation in recorded emissions, even when users with no recorded trips are excluded from the analysis. Users with no trips recorded were excluded from this analysis.

DISCUSSION AND CONCLUSIONS

This paper presented the results of a field trial to examine the impact of medium term use of an environmentally themed journey planning application on individuals' transport behaviour. This method of emissions information provision was chosen as a wide range of organisations are currently providing such information via digital platforms such as online journey planners and smartphone applications. Organisations, both public and private sector, are clearly committing resources to development of such applications and journey planners to provide users with emissions information, yet there is very little empirical research to date assessing its effectiveness, in terms of either users' receptiveness or inducted behaviour. Such applications have only emerged in recent years due to advancements in digital media and mobile Internet, and represent an opportunity to make emissions information more personalised and relevant to the individual user, and therefore present a new research opportunity with regard to the role of technology in transport behaviour. To test the effectiveness of such technologies, a number of different experimental techniques were undertaken as part of the field trial. The results of the pre-trial information assessment experiments highlighted an issue with regard to users failing to assess the emissions information that they were presented with. If individuals are not considering the emissions information presented to them it is not possible for this attribute to play a role in their decision making process. This would suggest that interface designers who wish to promote sustainable transport choices should employ methods of making emissions information more visible and relevant to the application user.

In terms of the role of emissions information provided by journey planners can play in altering behaviour, the results of the trial can be described as somewhat inconclusive. While an examination of recorded emissions displayed an initial decrease, after Week 4 CO_2 emissions rebounded to higher than original levels. The user comments indicated that while some users found that the information supplied by the application encouraged them to travel in a more sustainable manner, others highlighted issues such as lack of motivation or existing barriers to behaviour change.

From the point of view of policy makers and practitioners it appears the use of smartphone applications may be an effective method of providing individuals with emissions information that is personally relevant to them, however it may not prove to be an effective instrument of behaviour change in isolation. However, as such technologies and approaches continue to improve there is emerging scope to create more personalizable applications with the aim of providing transport recommendations that are more suitable to the individual user.

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REFERENCES

1. IPCC 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

2. Anable, J., Lane, B., Kelay, T. (2006) An evidence base review of public attitudes to climate change and transport behaviour. Retrieved (December 2, 2014) from http://www.dft.gov.uk/sustainable/climatechange

3. Quartz. (2014) These are the 25 most popular app in America. http://qz.com/253527/these-are-the-25-most-popular-mobile-apps-in-america/ Last Accessed 27.03.2015

4. Pitt, L.P, Parent, M., Junglas, J., Chan, A., and Spyropoulou, S. (2011). Integrating the smartphone into sound environmental information systems strategy: Principles, practices and a research agenda. *Journal of Strategic Information Systems* 2011, 20, pp 27-37

5. National Transport Authority [Website]. Transport for Ireland National Journey Planner. http://www.journeyplanner.transportforireland.ie/nta/XSLT_TRIP_REQUEST2?language=en . Last Accessed 28.04.2015

6. Hit the Road [Website]. Available at: http://hittheroad.ie/. Last Accessed 28.04.2015

7. Dublin Bus (2014) [Online]. Available at http://www.dublinbus.ie/en/your-journey1/mobileapps/

8. Luas (2015), Luas [Mobile Software Application]. Available at: https://play.google.com/store/apps/details?id=ie.dovetail.rpa.luas&hl=en. Last Accessed 28.04.2015

9. Google (2015) The Google Directions APIhttps://developers.google.com/maps/documentation/directions/
Google Maps [Website]. Available at: https://www.google.ie/maps/preview. Last Accessed 28.05.2015

10. Lyons, G. (2006). The role of information in decision making with regard to travel. *Intelligent Transport Systems,* 153 (2), pp 199-212

11. Chorus, G.C., Molin, E.J.E., Arentze, T.A., Hoogendoom, S. P., Timmermans, H. J. P., and van Wee, B. (2007). Validation of a multimodal travel simulator with travel information provision. *Transportation Research Part C*, 15, pp 191-207.

12. Watkins, E.K., Ferris, B., Borning, A., Rutherford, G.S., and Layton D. (2011) Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. *Transportation Research Part A*. 45, pp 839-848

13. Whitmarsh, L., G, Seyfang, and O'Neill,S. (2011) Public engagement with carbon and climate change: To what extent is the public 'carbon capable'? *Global Environmental Change*, 21, pp 56-65.

14. Brazil, W., Caulfield., B., Testing individuals' ability to compare emissions from public transport and driving trips, *Journal of Public Transportation*, 2014, 17, (2)

15. Brazil, W., Caulfield., B., (2014). Does green make a difference: The potential role of smartphone technology in transport behaviour. *Transportation Research Part C: Emerging Technologies*, pp 93-101

16. Avineri, E., and Waygood E.O.D. (2013) Applying valence framing to enhance the effect of information on transport-related carbon dioxide emissions. *Transportation Research Part A,* 48, pp 31-38

17. PEACOX [Online] 2015 Available at: http://www.project-peacox.eu/

18. Brazil, W., Caulfield., B. (2013) Factors affecting the use of transport related smartphone applications, *9th ITS European Congress*, *Dublin*

19. Spring (2015) Java Spring Framework http://projects.spring.io/spring-framework/

APPENDIX

Table i outlines the trips and searches made by each of the field trial participants and also a ratio of searches made to trips taken indicating certain users performed far more searches per trip taken than others.

TABLE I: SEARCHES AND TRIPS LOGGED PER USER

User	Trip searches	Trips taken	(Taken/Searched)
1	30	6	20.0%
2	17	2	11.8%
3	72	13	18.0%
4	13	4	30.8%
5	13	3	23.1%
6	6	1	16.7%
7	38	23	60.5%
8	98	51	52.0%
9	24	10	41.7%
10	31	10	32.3%
11	52	27	51.9%
12	115	50	43.5%
13	10	1	10.0%
14	0	0	0.0%
15	80	14	17.5%
16	28	4	14.3%
17	6	0	0%
18	16	14	87.5%
19	4	0	0%
20	4	0	0%
21	13	4	30.8%
Total	670	237	35.8%
Average	31.9	11.28	
Standard Deviation	32.9	15	

Table ii outlines the average per trip carbon dioxide emissions for each of the participants in the field trials

TABLE II: EMISSIONS LOGGED PER USER

User	Average per trip Emissions
1	0g
2	173g
3	1087g
4	0g
5	1639g
6	588g
7	41g
8	149g
9	83g
10	947g
11	790g
12	412g
13	61g
15	1149g
16	282g
17	0g
18	444g
21	639g
Standard Deviation	476g
Standard Deviation (Zeros Removed)	476.g

Table iii outlines the results of the breakdown of information assessment in terms of the different trip types presented. While there is a certain amount of variation, it is clear that in all cases time appears to be considered the more important trip attribute. Where:
T= Only Travel Time, E= Only Emissions, T-E= First Time, then Emissions, E-T= First Emissions, then Time

TABLE III: INFORMATION ASSESSMENT BY TRIP TYPE

Scenario	Description	Restrictions	Time	Ems	T-E	E-T
1	Home to Work	No Restrictions	57.1%	4.8%	38.1%	0%
2	Work to Home	No Restrictions	52.4%	0%	47.6%	0%
3	Home to Work	No Car	38.1%	0%	61.9%	0%
4	Work to Home	No Car	42.9%	4.8%	52.4%	0%
5	Home to Work	Bad Weather	61.9%	4.8%	33.3%	0%
6	Work to Home	Bad Weather	52.4%	0%	47.6%	0%
7	Home to Shopping	No Restrictions	66.7%	0%	33.3%	0%
8	Home to Friend's House	No Restrictions	28.6%	9.5%	52.4%	9.5%
9	Home to Friend's House	No Car	31.6%	10.5%	52.6%	5.3%
10	Home to Sports Arena	No Restrictions	45%	15%	40%	0%
11	Home to Concert Venue	No Restrictions	42.9%	9.5%	47.6%	0%
12	2km Trip	No Restrictions	33.3%	9.5%	57.1%	0%
13	2km Trip	No Car	33.3%	4.8%	61.9%	0%
14	2km Trip	Bad Weather	47.6%	0%	52.4%	0%
15	5km Trip	No Restrictions	52.4%	4.8%	42.9%	0%
16	5km Trip	No Car	38.1%	9.5%	52.4%	0%
17	5km Trip	Bad Weather	57.1%	0%	42.9%	0%
18	>10km Trip	No Restrictions	57.1%	9.5%	28.6%	4.8%
19	>10km Trip	No Car	42.9%	19%	38.1%	0%
20	>10km Trip	Bad Weather	52.4%	4.8%	38.1%	4.8%

Sample size: N=420