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Development of a technological platform for implementing VTBC programs

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Abstract

This paper presents the architecture of a technology platform constructed for the purpose of conducting personalised campaigns for promoting sustainable transportation. In particular, the proposed platform is designed to automate phases and activities of a Voluntary Travel Behaviour Change programme (VTBC), with a view to extending it to the large scale, reducing the resource commitment. A VTBC pilot test on a small convenience sample is also presented that aims to better define some features such as form and content of Personalised Travel Plans (PTP) and reinforcing messages provided to participants with a view to encouraging sustainable travel behaviour.

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014

Keywords: Voluntary Travel Behaviour Change programme; Personalised Travel Plans; Information; Persuasion; Technology.

Nomenclature

VTBC	Voluntary Travel Behaviour Change
PTP	Personalised Travel Plan
Avg.	Average

1. Introduction

The ever-increasing problem of traffic congestion caused by over-use of the private car affects our everyday lives in terms of wasted time, high costs, local and global pollution, public health, safety, social exclusion and so forth. Undeniably, the private car remains the favourite means of transportation for most people.

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Faced with these difficult and complex issues, many researchers have attempted to find ways of reducing private car use and mitigating its externalities. A variety of approaches is reported in the literature aimed at changing travel behaviour and at solving functional and environmental issues. These approaches, designed to encourage people toward a more efficient use of transport systems, are called "soft measures" (Cairns *et al.*, 2008) and form part of the broader field of Transport Demand Management strategies (Gärling and Fujii, 2009). Soft measures aim to modify car-related travel behaviour. They use information and communication to make individuals aware of the existing travel mode alternatives and of the impact of their behaviour at the personal and societal level (in terms of time, cost, CO_2 emissions). These measures are also known as "Voluntary Travel Behaviour Change" programmes (VTBC) (Ampt, 2003), as they attempt to persuade individuals to voluntarily change their behaviour. When information and communication are addressed to a single user and provide personalised sustainable car alternative solutions, these measures are known as Personalised Travel Plans (PTP). Personalisation, in fact, is the most effective means of reducing or eliminating barriers to information listening and of promoting behaviour change (Gärling and Fujii, 2009). However, several studies have demonstrated that information provision alone may not be effective in inducing people to change their behaviour (*e.g.* Abrahamse *et al.*, 2005). Indeed, the provision of information is just one of the elements of the process that attempts to evoke behaviour change, which comprises other elements and communication and persuasion techniques which are founded on a thorough knowledge of human behaviour. Currently, the most popular VTBC programmes provide information through traditional dissemination channels (direct contact with a consultant, mailing letters, brochures, posters, *etc*.) or through purpose-built websites. Additionally, if the campaign is on a large scale it is difficult to maintain a high level of customisation.

In this context technology can play an important role in improving a VTBC programme, as it is able to automate various tasks, such as capturing, processing and delivering information. In particular, the recently emerged persuasive technology research field concerns the environment and technological systems designed to help change the cognitive process, attitudes and behaviour (Fogg, 2003; Fogg, 2009).

The objective of this paper is to identify a means of replacing the traditional information provision methods with a direct, automatic, instantaneous and dynamic system that is able to send clear and persuasive information and advice to mobile devices. This system can be configured as a real "technology platform" useful for implementing a large-scale VTBC programme at an acceptable cost. For information acquisition, analysis, processing and transmission, the platform will be required to manage a marketing campaign on sustainable mobility, providing a personalised programme, similarly to a real mobility supervisor, constantly supporting people in their travel choices and encouraging them towards environmentally sustainable behaviour, thereby reducing CO_2 emissions and the negative impacts of car use.

In this paper a pilot test on a convenience sample is presented. In this first step, the attention is focused on two aspects: system automation and participants' acceptability of some features of the technology platform, such as personalised information provision (through Personalised Travel Plans) and persuasive effects of reinforcing messages. The paper is organised as follows: Section 2 provides a literature review. Section 3 describes the structure of the "IPET" platform. Section 4 focuses on the pilot test carried out on a convenience sample in the metropolitan area of Cagliari. Section 5 summarises the results and our main conclusions.

2. Literature review

Since the 1990s increasing attention has been focused on the implementation of soft measures aimed at influencing people's travel behaviour through information provision. Among the most important and well-known implementations on the international scene, are the many experiences of Travel Feedback Programmes (Fujii and Taniguchi, 2006), the Travel Blending (Rose and Ampt, 2001) and TravelSmart (Stopher *et al*. 2009), IndiMark (Brög *et al.*, 2009) and Personalised Travel Planning in the UK (Cairns *et al*., 2008). A major feature of these strategies is the personalisation of information provided to users. This aspect is certainly a key factor for the effectiveness of these programmes, as demonstrated by Gärling and Fujii (2009). The level of personalised information could significantly increase the effectiveness of these behaviour change programmes: the greater the level of information customisation of a VTBC (and the longer the data-collection period), the greater its effectiveness will be (Gärling and Fujii, 2009). Nevertheless, it also involves limitations as to the size of the sample

recruitable for the implementation: the more customised travel behaviour monitoring and the suggestions given are, the smaller the sample involved (Rose and Ampt, 2001; Fujii and Taniguchi, 2006).

In this context, one emerging issue is to understand how technology could be exploited in soft policy measures to improve the procedure as a whole, broadening its applicability while maintaining effectiveness. Technology, indeed, could contribute to improving the operational and functional aspects, through the implementation of automated VTBC programmes that exploit the added value of persuasive technology. Having demonstrated, through the traditional behaviour change programmes, that humans can persuade humans, the next step is to study how far persuasive technology can be stretched to improve the promotion of sustainable travel behaviour.

IJsselsteijn *et al.* (2006) claim that technology plays an important role in facilitating the delivery and administration of persuasive messages to convince people to buy, donate, vote or act in a particular way. Technology becomes, therefore, a powerful tool when it allows one to accomplish persuasive techniques that are *interactive* rather than *one-way*: that is, when technology enables one to adjust (adapt) and alter the patterns of interaction with users on the basis of their characteristics or actions performed. Basically, technology can offer four main advantages for improving the effectiveness of a VTBC programme: (1) a high level of personalisation in data/information collection, (2) the provision of real-time and timely personalised information, (3) the ease with which information can be acquired and (4) automation of the whole procedure for large-scale implementation. All of these aspects make it possible to implement VTBC programmes that are able to involve as many participants as possible, with a minimum of effort and costs in terms of workforce for its management.

One key tool that has made it possible to further improve persuasive technology is the smartphone. It is estimated that by 2015 approximately 80% of internet users will gain access via their mobile phone (Johnson *et al.*, 2010), enabling widespread access to information. This has led to the emergence of the so-called mobile persuasion (Fogg, 2007), the natural and direct evolution of persuasive technology, which operates exclusively in a "mobile" environment. Subsequently, various applications for smartphone appeared, aiming to persuade people to change certain behaviour. These are mobile applications (“app”) that operate in different areas: health, physical activity, promotion of eco-friendly behaviour in general. In particular, some interesting applications for smartphones have been developed recently in the transportation area. Some examples are Ubigreen Transportation Display (Froehlich *et al.*, 2009), Quantified Traveler (Jariyasunant *et al.*, 2013), MatkaHupi (Jylhä *et al.*, 2013), Peacox (Schrammel *et al.*, 2012), SuperHub (Carreras *et al*., 2012).

Ubigreen Transportation Display (Froehlich *et al.*, 2009) consists of a mobile application that heightens awareness about sustainable travel behaviour through feedback. Small visual/graphic rewards are received by users every time they travel sustainably: on foot, by bike, bus, train or carpooling. The distinctive feature of this application is that, in response to the travel behaviour automatically detected, the homescreen background of the smartphone is changed with the aim of promoting sustainable trips. Users also earn points (credits) for sustainable travel.

Quantified Traveler (QT) (Jariyasunant *et al.*, 2013), instead, consists of a computational travel feedback system, in which feedback about the movements is used to change travellers’ mode choice or trip choice. QT is based on a computational system that replaces the role of travel consultant, in an automatic fashion. QT is able to passively collect user data (through GPS and other automated sensors), convert them into a travel diary, quantify feedback in terms of time and money spent on travel, calories burned and CO_2 emitted, and, finally, provide users with the results.

MatkaHupi (Jylhä *et al.*, 2013) is an application able to motivate people into choosing sustainable modes of transportation, relying on a set of challenges. The peculiarities of this application are represented by the challenges that are continually offered to users based on their observed behaviour. After each detected trip, the system checks whether the same trip could have been made faster (less travel time) and/or with lower emissions (trip challenge) using a sustainable alternative. Therefore the application challenges the user to consider, in the future, the alternative trip proposed. If the user takes up the challenge, then he/she is rewarded with a badge and a certain number of points, depending on the type of challenge.

Peacox (Schrammel *et al.*, 2012), instead, is an application that aims to provide users with customised tools for multimodal navigation, which helps and persuades them to plan their trips in a more eco-friendly way. An interesting feature is represented by the real-time feedback that, depending on the particular travel behaviour monitored, changes the smartphone background.

Lastly, SuperHub (Carreras *et al*., 2012) is based on the big-data approach applied to mobility ecosystems.

Exploiting advanced reasoning techniques and data analysis tools, SuperHub automatically collects different types of data (public transport and road traffic information, GPS data, weather/pollution *etc*.) and processes them in order to provide users with personalised and "green" journey plans.

In short, exploiting the most recent developments in technology is the key to revolutionizing the whole VTBC program implementation procedure: from data collection, analysis and processing to deployment of personalised information and user/platform interaction management. Everything is managed via a smartphone application that provides an interface between users and the complex computational system that collects, analyses and processes data. This makes it possible to automatically manage a large amount of data and information, thus permitting implementation of customised programmes for changing travel behaviour at the large-scale.

3. IPET platform

IPET, acronym for *Individual Persuasive Eco-Travel Technology*, is a technology platform for implementing a large-scale VTBC programme. In particular, this platform makes it possible to collect and process activity-travel data and automatically deliver information. Technically, the IPET architecture is composed of 5 elements: (1) Mobile application (Activity Locator), (2) Server, (3) Analyser, (4) Simulator, (5) Information delivery. The architecture is described in Fig. 1.

The Activity Locator (1) (Meloni *et al.*, 2011; Meloni and Sanjust, 2014) is a mobile application that can be installed in any smartphone (Symbian, Android and IOS platform) with built-in GPS currently available on the market. The application tracks individual daily routes in real time and collects all activity-travel related information through a sequence of pull-down menus that reproduce the classical activity-travel diaries. The main difference with traditional paper activity-travel diaries is that activities are recorded in real time, instead of at the end of the day at home.

Data recorded by the Activity Locator application are instantly sent to a Server (2) via an Internet connection, making them immediately available for download in the required format (*e.g.* xls, csv, *etc*.). The server collects the information sent by each participant and once stored, conveys all the data to the Analyser (3) which analyses activity-travel data and converts them into an activity-travel diary.

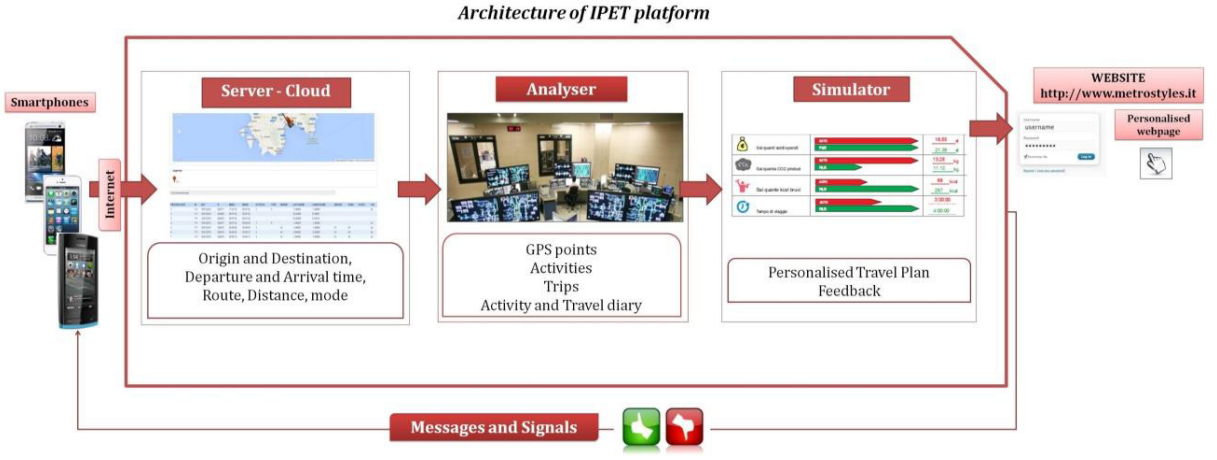

Fig. 1. IPET platform.

In this phase the analyser automatically calculates all the attributes related to monitored activities and trips. In particular, it calculates the time spent in- and out-of-home activities (for different purposes and company). Travel behaviour is analysed for different travel mode options; for each mode travel times, costs, distance travelled, CO_2 emitted (motorised modes) and calories burned (active modes) are calculated. These four elements represent the quantitative feedback related to the observed behaviour.

The Simulator (4) receives the diaries accompanied by quantitative feedback and then identifies a sustainable

alternative to be proposed in place of the motorised one, in order to persuade individuals to change their travel behaviour. In particular, the simulator devises a personalised travel plan (PTP) for each user, accompanied by feedback related to the observed and suggested behaviour. This information is sent to each individual (a) via mail and (b) to a personal website area, that each user can visualise after logging into the project website.

Information is also transmitted using brief persuasive messages (c), that combine text and images in different forms (cartoons or realistic images). After the PTP provision, depending on the users' observed travel behaviour, these messages can express either regret or congratulations. If users prove to have successfully followed the sustainable advice, then they will be congratulated; conversely, if they continue to use the car for their trips, the message will express regret. The aim is to reinforce the message transmitted by the PTP, making users feel proud if they reduce car trips (and, therefore, if they use public transport, along with cycling and/or walking), or guilty, if they prove to be addicted to their car.

The combination of PTP and messages for persuading people to reduce their car use plays a very important role. Indeed, the design and presentation of information need to be carefully thought out so as to pursue the goal as effectively as possible. The information and communications provided, along with the graphics, are fundamental for effective persuasion. As suggested by Gaker and Walker (2011), presenting information is a delicate aspect that can have repercussions on participants' propensity to accept the proposed suggestions. Notions need to be accurately and clearly presented in a way that can attract participants. Thus, the personalised travel plan, the feedback and the messages must be able to make information easy to understand, reliable and acceptable. Persuasive graphics are used for the representation. Special attention was paid to presenting the cost/benefits associated with the observed and proposed transport alternative. Further, different forms were considered for the messages. In particular, praise/regret messages were presented using both graphical and numeric values, together with images (cartoons/realistic pictures) depicting the environmental impact they generate. Appeal and clarity are very important for the message to be effective (Economic & Social Research Council, 2008). Another important aspect is the "active" interaction between individual and platform that makes it possible to continuously involve participants in the programme. Indeed, although automatic spatial data collection is possible via GPS, the active mode used for recording activity and trips via the app heightens participant motivation and awareness of the important role they play in making the project a success. Further, with the active mode it is possible to immediately identify participant behaviour and therefore use real time persuasive messages.

4. The pilot test

The pilot test concerned the implementation of a personalised VTBC programme aimed at reducing car use. In particular this experiment tested participant response to the information provided, in terms of content and presentation. The test, conducted in Cagliari, lasted two weeks and comprised three steps: recruitment, programme implementation and the final questionnaire.

Recruitment phase: the first step comprised a preliminary Focus Group (FG) and an initial questionnaire. The purpose of convening the focus group was to evaluate beforehand the main perceptions, attitudes and motivations concerning private car use and the existing alternative sustainable modes (walking, cycling, bus, light rail, train).

The objective of the FG was to gather qualitative information about the general transportation context and therefore identify the most appropriate suggestions to be included in the personalised travel plan.

Participants were required to own a smartphone with an active internet connection. A sample of 15 users was selected for participating in the pilot study.

Implementation of the programme: the pilot test comprised two waves. During the first wave (3 working days) participants were required to use the Activity Locator, completing real time activity-travel diaries. Information gathered was stored, analysed and a personalised travel plan (PTP) was created for each participant. PTP provision is a crucial phase of this pilot study, insofar as car use reduction is closely related to the PTPs' feasibility and appeal, in turn closely related to its design (in terms of form and content). The PTP consisted of a pdf page format containing different information; it was sent via email, and was also published on the personal web page. An example of the PTP is shown in Fig. 2.

The PTP is divided into 4 sections. (1) a map of observed behaviour, (2) a map of the recommended sustainable option, (3) a table of personal feedback and (4) general information.

Unsustainable behaviour is highlighted in red on the maps, to emphasise the negative connotation associated with private car use, whereas the sustainable alternatives suggested are shown in green (positive connotation).

The feedback table indicates, on a weekly and annual basis, the four aspects strictly related with travel behaviour: travel time and cost, CO_2 emitted and calories burned (Jariyasunant *et al*., 2013). Through this table users can easily compare the weekly and annual costs of actual behaviour (car-use) and benefits of the sustainable alternative. The four aspects are again coloured green and red; values for sustainable modes are green, those for the private car red (negative connotation). Next to each of these values, a bar shows the corresponding measure: the greater the value the longer the bar. This makes the comparison between car-related and sustainable-mode attributes even more immediate. Besides, these bars have the same colours, green for the sustainable alternative red for the private car. In addition to the PTPs, users also received a link to their personal web page where they could find useful information about the pilot study and its participants. They could retrieve information about their observed travel behaviour, check their PTP and travel feedback, and compare their results with other participants.

The second wave differs from the first in that reinforcing messages containing text and images are also sent (Fig. 3 and Fig. 4). During each day of the second wave, users received 3 messages: in the morning, afternoon and evening. The purpose of these messages was to encourage them towards the sustainable travel choices contained in the PTPs: so the idea is that PTPs and messages could jointly contribute to inducing users to change their (bad) travel habits. Depending on users' travel behaviour during the second wave, messages could express:

- Regret (Fig. 3*): this means users continued to travel by car instead of trying the sustainable alternative suggested. The aim of these messages is to make users feel guilty about their travel behaviour and about having wasted the opportunity to take advantage of the benefits associated with the sustainable alternative suggested in the PTP. This kind of message contains images recalling car use externalities, challenging texts and has a red background, strengthening the negative connotation related to private car use.
- Congratulations (Fig. 4†): this means, conversely, that users tried out the sustainable alternative suggested. The aim of these messages is to make users feel proud and satisfied with their travel behaviour. This kind of message contains images that recall green transportation and sustainability, approval texts and have a green background, confirming the right travel choice just made. These messages are sent automatically by the system in response to the travel behaviour monitored.

Final questionnaire and user comments/impressions: the last phase of this pilot study was the final questionnaire (compiled online), in which users were asked to give their impressions of the different aspects of the experiment. The aim was to gather useful feedback for the VTBC programme as a whole and in particular the persuasion tools (PTP and messages). Each aspect was evaluated through a series of statements to which participants assigned a score on a 5-level Likert scale (41 questions, see Table 1) expressing their agreement/disagreement or viceversa their preferences about suggestions for changing the experimental procedure. The questionnaire was the most important part of this work, as it enabled researchers to fine tune the programme as a whole with a view to larger-scale implementation. Out of the 15 individuals involved, 14 completed the final questionnaire. The analysis was therefore conducted for these 14 individuals.

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* The Messages are in Italian. Regret 1: <Never thought about carpooling? If you had, you would have saved money.>; Regret 2: <Your car pollutes! Use it less and travel sustainably.>; Regret 3: <Never thought about parking further away? Walking more is good for your health.>; Regret 4 <You kept polluting with your car. If had you taken the bus you would have emitted 5 times less CO_2>; Regret 5 : <You are a polluter! If you took our advice, you would have avoided that.>; Regret 6: <You have many reasons for not using the car. For short trips just walk.>.

† The Messages are in Italian. Congratulations 1: <Good! Today you haven't emitted CO_2. Taking the bus you have emitted 5 times less CO_2.>; Congratulations 2: <Today you've walked more than usual. Congratulations! It's even healthier for you>; Congratulations 3: <Today you haven't polluted with your car. You kept the air clean.>; Congratulations 4: <One car less is good for your health. Keep walking.>; Congratulations 5: <Good! Using the car less is not difficult. Keep walking for your short trips.>; Congratulations 6: <Today Cagliari is cleaner and better because of you. Keep doing this. Tomorrow travel sustainably.>.

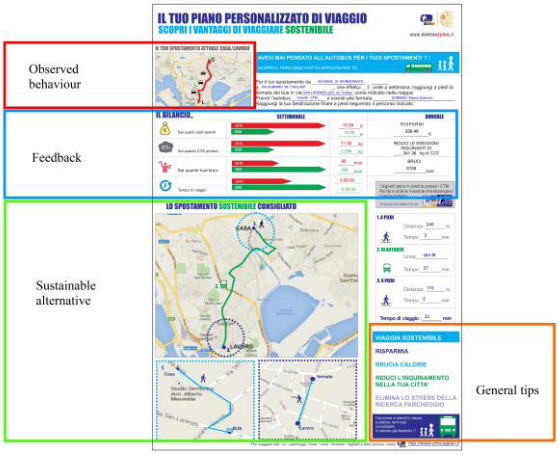

Fig. 2 - Personalised Travel Plan

Fig. 3 - Regret messages

Fig. 4 - Congratulation messages

5. Results of the final questionnaire and conclusions

Analysis of the responses revealed that almost all participants felt that the six-day survey was not too long, but acceptable (11 out of 14). Regarding the Activity Locator application, they did not find it difficult to use (avg. 1.36), needing just a couple of hours to learn how to manage it (10 out of 14 individuals).

They also added that the application was intuitive (avg. 3.36), though sometimes became boring (avg. 2.86) and required too much commitment (avg. 2.86). The most frequent technical problems reported were rapid battery consumption of the device (avg. 3.29) (this problem also arose in the first implementations of this application; Meloni and Sanjust, 2014) and occasional crashes which meant the application had to be restarted (avg. 3.64). These problems occurred more frequently than in the earlier applications of the AL. This is due to the fact that the current AL application is designed for Android and IOS environments, and perhaps needs to be improved (Meloni and Sanjust, 2014).

All participants found that the PTP they received was clear and easy to understand, and they all appreciated the way in which it was delivered (just one individual would have preferred to receive the PTP via a link to a personal web page). Regarding the content, the most appreciated aspect were the maps showing the monitored car route and sustainable alternatives (avg. 3.93). The suggested alternative was also clearly explained (avg. 3.50). Moreover, users stated that the PTP heightened their awareness about the environmental and health benefits of using sustainable means of transportation (respectively avg. 3.14 and 3.07) and though the information provided was already known, it had never been quantified before (avg. 3.57).

Regarding the feedback provided, users indicated travel time as the most important feedback (avg. 4.71), followed by travel costs (avg. 4.29), CO_2 emitted (avg. 3.21) and, lastly, calories burned (avg. 2.93).

As for representation of the PTP, users found the colour code used to distinguish car use (red) from sustainable alternatives (green) useful and intuitive (avg. 3.50).

Reinforcing messages were well accepted: the participants found them easy to understand and clear and quite useful for encouraging sustainable behaviour (avg. 3.00), even if predictable (avg. 3.79). They appreciated the good display quality on their smartphone (avg. 4.21). As shown in Figs. 4 and 5, three different kinds of messages were used: text and smile, messages containing text and a cartoon image, and messages containing text and a realistic image. Out of these three types of reinforcing messages, 50% of participants preferred the first (7 out of 14), namely text and cartoon images.

The personal website was visited by the majority of participants (12 out of 14). Further, all the participants who visited the website found the possibility of comparing their results with others very useful. Finally, participants were asked to provide researchers with some tips about their experience. Thus, some interesting suggestions emerged. A number of participants thought it would have been more useful to receive PTPs for a variety of trips, not just the home-to-work journey. For example, one participant would have appreciated also receiving tips about the return work-to-home trip. Others would have preferred receiving personal travel suggestions in real time or, anyway, before they started the trip. Concerning the application (AL), users agreed that it needed to be improved to avoid the app crashing.

The findings suggest that the commitment required for using the app was acceptable; the personalised information provided was clear, easy to understand and particularly appreciated (*e.g.* maps, form and colours of PTP). Participants also appreciated the reinforcing messages, that proved easy to read on the smartphones, acceptable and clear. Further, interesting suggestions emerged, regarding PTP transmission, suggestions provided, and timing of messages to be sent. These elements could prove useful for improving the presentation of the information (personalised travel plan) provided, and in general, for the implementation of a Voluntary Travel Behaviour Change program conducted through a technology platform.

Future developments will concern continuation of the test phase on a larger sample, focusing on both single elements and the entire sequence of activities carried out by the platform.

Table 1.Final questionnaire responses

	Item	Mean	Dev. St.
The Activity Locator	Difficult to use	1.36	0.50
	Boring	2.86	1.23
	It requires too much commitment	2.86	1.23
	It requires too detailed information	2.93	1.44
	GPS violates privacy	2.93	1.49
	It is intuitive	3.36	1.15
	It is fun	2.14	0.95
	It is innovative	2.86	1.23
	It is a waste of time	1.64	0.74
	Battery consumption	3.29	1.68
	Too many activity options in the menu	2.50	1.22
	Smartphone debug	3.14	1.23
	The smartphone is slower	2.29	0.99
	It is difficult to find the right activity to send	2.36	1.15
	Application debug	3.64	1.08
The PTP	Maps are useful to understand the proposed behaviour	3.93	1.33
	The information is useful	2.07	1.38
	The proposed trip is clearly explained	3.50	1.40
	PTP contains useful information	2.00	1.24
	PTP contains too much information	1.86	1.10
	Colour code helps to read the PTP	3.50	1.16
	It heightens awareness about environmental benefits	3.14	0.95
	It heightens awareness about health benefits	3.07	1.00
	Information provided is unnecessary	2.29	1.14
	It provides information already known but never quantified before	3.57	0.94
	It is useless for reducing car use	2.71	0.99
	It represents an incentive to try alternative modes to car	2.79	0.97
	Travel time	4.71	0.47
	Travel cost	4.29	0.83
	CO_2 emitted	3.21	1.05
	Calories burned	2.93	0.83
The Messages	They are intrusive	2.57	1.22
	They are clear	4.57	0.65
	They make you think about travel behaviour	3.14	1.17
	They provide predictable information	3.79	1.25
	They clearly explain the message	4.29	0.83
	They are ridiculous	2.50	0.85
	They are useful for encouraging sustainable travel behaviour	3.00	1.24
	They are counterproductive	2.07	1.38
	They are annoying	2.43	1.40
	Easily readable on smartphone	4.21	0.89

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