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Impacts of Advanced Travel Information Systems on Travel Behaviour: Smartmoov' case study

ABSTRACT

Which are the effects of multimodal real-time information on travel behaviour? Significant amounts of money have been invested to implement such systems in urban environments, but until now only few assessments have been done to verify if they contribute to a modal shift and to more sustainable mobility. This research aims at thoroughly assessing the effectiveness of multimodal real-time travel information systems, pointing out the limitations before their use and recording the changes induced on the travel behaviour. Two questionnaires were designed and executed before and after a five-month period of testing a multimodal real-time travel information application for Smartphones (Smartmoov') implemented in 2013 in Lyon. Descriptive analysis, parametric and non-parametric tests, factor analysis and binary logistic regression were used as statistical approaches to analyse the collected data and evaluate the effectiveness of Smartmoov'. Before the test, participants declared an interest on Smartmoov' and a positive attitude towards its use: almost everyone was able to use technological tools and was familiar with the concept of Smartmoov'. At the onset of the test, travellers' evaluation towards the travel planner was slightly positive, but this decreased over time, while the use of the different modes remained stable after the test, albeit a small increase of the car for the most frequent trip was observed. Consistency on the most used mode, on behavioural patterns and attitudes show that mobility is strongly related to habits and, thus, to the frequency of the past behaviour.

Key words: Travel Behaviour, Information Systems, Theory of Planned Behaviour, Modal shift.

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INTRODUCTION

Transport of goods and people is an important driver of the global economic growth and prosperity because it enables trading and people connectivity**.** In Europe during 2011, the transport sector was responsible for 33% of the final energy consumption and for approximate 5000 million tonnes of CO_2 equivalent of greenhouse gases per year, while a continuous growth of these numbers is expected (European Commission, 2013). This leads to the major question that transport research groups have been trying to answer for years: how to maintain the freedom and prosperity that transport provides to today's society without increasing air and noise pollution, congestion, fatalities, and greenhouse gases. The goal is to make the mobility more efficient and sustainable, both for passengers and goods, being one of the basic pillars in the new economic growth paradigm in a low carbon world.

One of the current challenges is to use Advanced Traveller Information Systems (ATIS), notably the multi-modal solutions, to make mobility more efficient and sustainable. These systems are seen as an encouragement for travellers to make the best use of the available transport modes and to support an integrated, sustainable transport system throughout Europe.

Under this vision, significant amounts of money have been invested to implement such systems in urban environments, but, until now, few assessments have been done to verify the extent to which they contribute to the modal shift and to get a more sustainable mobility.

ATIS are intended to assist travellers in planning and decision making for mode choice, departure time, and route choices, including congestion avoidance, to improve the convenience and efficiency of travel. The impact and effectiveness of ATIS, however, critically depend on traveller's responses to these systems and to the information that they offer. Therefore, it is essential to understand the traveller's decision making process under real-time information (Abdalla & Abdel-Aty, 2006). If, and in what way, systems like these have an effect is highly dependent on how they are co-opted by users. Manifestly, this is not only a technological, but also a social process, which merits technology assessment (Gotzenbrucker & Kohl, 2011).

It is not easy to define and document ATIS impacts and quantifying ATIS benefits has been especially difficult, due to the lack of real-world environments in which travellers' behaviour, under the influence of ATIS, can be observed (Abdel-Aty, 2002). However, there have been several attempts to quantitatively and qualitatively evaluate ATIS benefits. The previous studies used mainly three methodologies to assess these benefits, namely: surveys, field experiments or simulations and assignment methods (Williams et al., 2008).

Still, there is not a well-defined social-economical profile of the users of ATIS, showing that these systems can be used by everyone and that the biggest limitation in their use comes from the lack of awareness of their existence.

People tend to use ATIS during the peak hours, in the unfamiliar and arrival time-sensitive travels, but they are not willing to pay for obtaining this kind of information.

Information is a key factor in today's' mobility, having a high potential for optimizing the choice among the travellers' options. However, to profit of its potentials, information has to be provided in an accurate and structured way and the travellers have to be totally engaged in using them. It was understood as well that past behaviour and habits are not always a good predictor of future behaviour (Bamberg et al., 2003).

Complex human behaviour is cognitively regulated and, even after numerous enactments, appears to be subjected to at least some degree of monitoring. As a consequence, the new information provided by ATIS, if relevant and persuasive, could produce changes in attitudes, subjective norms and perceptions of behavioural control, affecting intentions and being able to influence later behaviour in the higher end (Bamberg et al., 2003).

Therefore, the objective of this research is to bridge the gap in the existing literature by presenting the results of a research project (Optimod'Lyon), analysing the effects on transport users' behaviour of the real-time multimodal information provided by the journey planner Smartmoov'. This paper aims at thoroughly assessing the effectiveness of multimodal real-time information systems, pointing out the limitations before their use and recording the changes induced on the travel behaviour.

METHODOLOGY

Two wave questionnaires were designed and administered before and after a five-month period of test of a multimodal real-time information application for Smartphones (Smartmoov'), implemented in the city of Lyon. 50 participants answered to the first questionnaire during February 2013 and 46 (4 of them dropped the test) answered the last questionnaire in October 2013.

The questionnaires were created using an online platform and the questions were the same on both surveys, with a differentiation related to the actual behaviour after the test. The questionnaires included four parts: Personal mobility habits, Personal Attitudes related to mobility, Familiarity and interest for technological tools and Smartmoov' application. The majority of the questions were on a 5-points Likert scale, because it represented a good compromise in terms of overload for the respondent (Groves et al., 2004). To avoid reporting errors the same scale was used throughout all questionnaires (Wholey et al. 2004). Since the total number of participants was about 50, it was not possible to use the central limit theorem neither the Shapiro-Wilk test to guarantee the normal distribution of the variables. Assuming that our data would never be exactly normally distributed and so, following Brown (2011) and Fife-Schaw (2013), we consider the variables relatively normal if Skewness and Kurtosis values range from -1.5 and +1.5. Descriptive analysis, parametric and non-parametric tests, factor analysis and binary logistic regression were used as statistical approaches to analyse the collected data and evaluate the effectiveness of Smartmoov'. The Statistical software used for these analyses was the BMDP Statistics Software (BMDP, 1992).

The theoretical basis of this research is the theory of planned behaviour (TPB). Throughout meta-analysis and some empirical studies, the TPB has been used in several applications in a wide range of domains. However, this research is one of the few attempts to use such a theory as a conceptual framework to study the effect of new technologies that might produce a change in travel behaviour. According to the aforementioned theory, it should be possible to influence intentions and behaviour by designing an intervention that has significant effects on three factors: attitudes towards the behaviour, subjective norms and perceptions of behavioural control (Ajzen, 1991).

RESULTS

Results are presented in two major sub-chapters. The first one, before the test of the Smartmoov' app, where the possible barriers to use the app and the theory of planed behaviour constructs are assessed. The second sub-chapter analyses the effects of the application on mobility, comparing the answers provided to the two-wave questionnaires.

Before the test of the app

Sample

In the first questionnaire 50 persons were involved, living in the Lyon metropolitan area that completed the entire online questionnaire before the testing the Smartmoov'. The selected sample presents a balance between genders. The age distributions range from 23 to 68 year-old, similarly distributed between both genders. The participants mean age is 42.44 years-old. On one hand 16 respondents have a high educational level and on the other hand, 34 respondents have not attended the university and two of them do not have any diploma.

Technological familiarity

The ownership of Smartphones is very high, 41 out of the 50 participants own one. Figure 1 shows that participants consider themselves as good users of technological tools (and notably of PCs, Smartphones, GPS navigators and MP3 players).

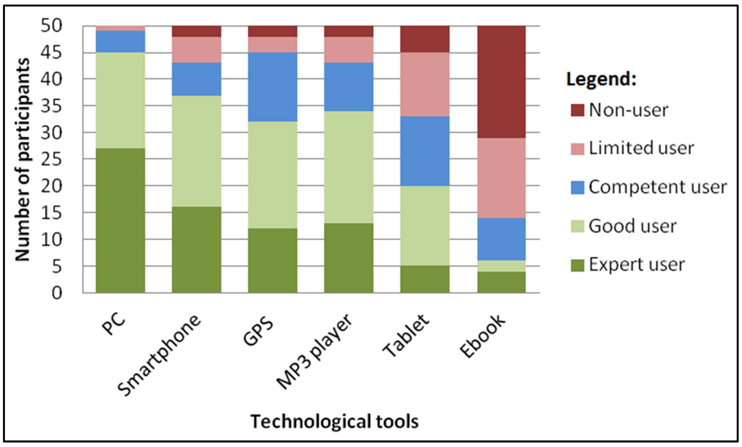

Figure 1- Familiarity with technological tools

Concerning information sources when choosing a route to an occasional place, the majority of the respondents uses internet to get the information needed (44). The second most used tool is the GPS navigator (31) and the third one the app like google maps (28).
The participants show a high level of interest towards technological devices, as observed by the high values central tendency indicators of the answers to the three questions reported at Table 1.

Table 1 - Interest about technology Statistics

	1. I would like to test new technological devices	2. I'm passionate by the potential of new technological Tools	3. I'm interest in technology
Mean	4.34	3.80	4.04
Median	5.00	4.00	4.00
Mode	5	5	5

More than half of the participants (27) agree that apps help them in their daily life, showing that apps for daily use are already a reality. More than half of the participants (31) find that some apps are enjoyable to use. About the willingness to discover new apps, 22 persons like to do it.

Behavioural constructs for the modal change

To identify the factor structure of the TPB, a principal component factor analysis with quartimax rotation was conducted on 10 questionnaire items. For samples with less than 60 participants, items only can be acceptable if communalities account at least .60 (Martinez and Ferreira, 2008). Therefore, two items were removed in the first analysis. In the second analysis, sampling adequacy (Kaiser_meyer_olkin) indicates a mediocre compact of correlations (.608) and the analysis of sphericity indicates a strong relationship between the items (df=28, p<.001), both of which show that factor analysis is appropriate for this measure. Factors were extracted on the basis of eigenvalue greater than 1 proportion of variance accounted, percentage of variance accounted, percentage of variance explained by each factor, number of items with significant factor loadings and factor interpretability (Kahn, 2006).
Considering all the above criteria, the best solution found was related to three main factors, accounting for 72.422% of the variance (Table 2).

Table 2 – Rotated Principal Components Analysis (PCA) Structure Matrix

Items	**TPB**	**Factor 1**	**Factor 2**	**Factor 3**
I expect that my family and friends put me under pressure to reduce the environmental impacts of my travels	SN	**.898**		
I expect that my family and friends incite me use Smartmoov'	SN	**.762**		
I expect that policy makers incite me use Smartmoov'	SN	**.754**		
I expect that policy makers put pressure on me to limit the environmental impacts of my travels	SN	**.753**		*.346*
I don't love driving for most frequent trip	ATT		**.883**	
I don't like to travel by car	ATT		**.882**	
I would use the Public Transport more often if I had real-time	PBC			**.809**

information				
I would use more the velov' (bike-sharing) if the real-time was available	PBC			**.784**
Eigenvalues		2.713	1.795	1.286
Percentage variance explained		33.908	22.436	16.078

Note: All factor loadings > .300 (or<-.300) are shown. Loadings of items used to identify each factor are in bold; other loadings are italicized. SN = subjective norms; ATT = attitudes towards the behaviour; PBC = perceived behavioural control.

The PCA gave a three-factor dimension, matching the proposal of theory of planned behaviour. Table 2 shows the rotated matrix and includes all loadings >.300. Loadings of the items used to identify each factor are in bold, while the other loadings are in italics. Factors were identified as representing attitudes towards the behaviour (ATT), perceived behavioural control (PBC) and subjective norms (SN). Eigenvalues for these factors were all above the threshold of 1 for factor retention (Kaiser, 1974). The three factors explained a total of 72.422% of the variability of the original eight variables. Therefore, the complexity of the data set can be considerably reduced by using these components, with 27.578% loss of information.

All items presented at least .60 of communality. Mean communalities value was .724 over threshold of .700. Finally, all items presented a loading factor above .600 (Budaev, 2010).

Cronbach's α was computed for the items used in identifying each factor: SN, α = .802; ATT, α = .739; PBC, α = .532. Values for all scales except perceived behavioural control reached the .700 threshold. Despite the PCB construct showed a poor value for internal consistency, but still acceptable, it was decided to use this PBC construct in the analysis because small samples size can deflate the Cronbach's α value (Cortina, 1993). Respondents' scores on reliable scales were computed by taking their mean on items comprising each scale, so that scores ranged from 1 to 5 (Table 3). For all TPB constructs the 50 participants, in mean values, scored near the middle point of the scale. Pearson correlation and Spearman's rho did not show any significant correlation among the three constructs, therefore the constructs are independent.

Table 3 – Factor Descriptive Statistics

Factor	Mean	S.D.	Min	Max	Skewness	Kurtosis
PBC	3.030	1.193	1.00	5.00	-.196 (S.E. = .337)	-.917 (S.E = .662)
ATT	2.890	1.279	1.00	5.00	-.088 (S.E. = .337)	-.941 (S.E = .662)
SN	2.775	947	1.00	5.00	.208 (S.E. = .337)	-.028 (S.E = .662)

The intention to change transport mode was asked on 1 to 5 scale. Answers 1 and 2 mean that they do not want to change mobility habits. Answer 4 and 5 mean that they intend to change mobility pattern. Answers on the middle point (3) were excluded because were undecided people. Table 4 shows descriptive statistics for people who express the intention to maintain or change their transport habits (hereafter, "maintainers" and "changers"). Higher values in the SN and PBC construct by the changers are coherent with the theory. However, the higher mean value in the ATT construct by the maintainers' is quite unexpected.

Table 4 – Descriptive statistics for theory of planned behaviour variables for different intentions

Intention	Constructs	Mean	Min	Max	SD	Variance	n
Maintain transport habits	ATT	3.259	1.00	5.00	1.259	1.584	27
	SN	2.704	1.00	5.00	1.070	1.144	27
	PBC	2.685	1.00	5.00	1.257	1.580	27
Change transport habits	ATT	2.0000	1.00	4.50	1.275	1.625	9
	SN	2.7500	1.75	4.00	.791	.625	9
	PBC	3.2778	1.50	4.00	.833	.694	9

Mann-Whitney tests showed no significant differences between maintainers' and changers' on SN (U=121, *p*=.985) and PBC (U=82.5, *p*=.149), but there is significant differences (*p*<.05) for ATT (U=56, *p*=.016). Changers had lowers attitudes toward the change transport mode.

Spearman's rho (ρ) correlations among variables were calculated and the three construct had not significant correlation among them. This indicated that multicollinearity would not be a problem in regressions using these variables as predictors (Field, 2000).

A logistic regression was used to understand the ability of the TPB model to explain the modal change intention. In this TPB regression, subjective norms, attitudes and perceived behavioural control were entered simultaneously. In this regression, ATT and PBC constructs were significant (*p*<.05) and SN construct was not. As follow-up it was built a model using forward stepwise method. Attitudes towards behaviour (ATT) was added to the model (Table 5). Subjective norms (SN) was left out of the analysis at the first step because had significance values larger than .05. However, even though, perceived control behaviour (PCB) had a significant value, it was left out on the last step because it did not contribute to better fit the model. For a logistic model, if the intercept is zero (equivalent to having no intercept in the model), the resulting model implies that logit (or log odds) is zero, which implies that the event probability is .5. This is a very strong assumption that sometimes is reasonable, but more often it is not. Therefore, a highly significant intercept in this model is generally not a problem (SAS, 2013).

Table 5 – Final Model

Predictor	Coefficient	SE	Coef/S.E.	*p-value*	Exp(coef)	95% CI Exp(coef) Lower bd	upper bd
ATT	.835	.373	2.24	.043*	2.31	1.08	4.92
Constant	-1.068	.954	-1.12	.302	.344	.050	3.29

* sig. at .05

As a further check, the backward stepwise method was used. The two methods choose the same variable, Attitudes towards behaviour (ATT), so we can be fairly confident that it's a good model. The Hosmer-Lemeshow test and the C.C. Brown test report that the model adequately fits the data, since the values were higher than .05 (Table 6).

Table 6 – Goodness-of-fit Test

Test	Chi-square	df	Sig.
Hosmer and Lemeshow	7.411	7	.387
C. C. Brown	.851	2	.653

The model is reported in the equation 1:

$$\Pr[\text{ Maintain}] = \frac{e^{-1.068+.835ATT}}{1+ e^{-1.068+.835ATT}}. \qquad [1]$$

Where the odds of maintaining the mode used increase by a multiplicative factor of 2.31 (Exp(a) = .835) for each absolute increment on the ATT score. Overall, 80.6% of the cases are correctly classified.

After the test of the app

Sample

As previously reported, the analysis carried out after the test involved 46 persons (four participants left the test). This sample maintains the gender balance. The ages range from 23 to 68 and are similar for both genders (t(44) = .723, *p* = .474) being the average age of the sample 43.04 years old (SD=12.18). Out of the 46 participants, 17 have a higher education degree, 29 have not attended the university and two of them do not have any diploma.

Expected and actual outcomes

Table 7 summarises the participant's agreement (those answered 4 and 5 to the likert scale), according to the expected and actual outcomes of the Smartmoov' app.

Table 7 – Agreement related to the expectations and revealed behaviour induced by Smartmoov' app

Participants claim to believe that...	**Ex_ante**	**Participants report that...**	**Ex_post**
SMARTMOOV' will be a facilitator towards a change in my mobility behaviour	19	SMARTMOOV' has facilitated a change in my mobility behaviour	3
I feel an incentive to change my mobility behaviour due to the use of SMARTMOOV '	17	I felt an incentive to change my mobility behaviour due to the use of SMARTMOOV'	9
I expect to gain time, thanks to SMARTMOOV '	42	I gained time, thanks to SMARTMOOV '	14
The mean value of three statements related to limit the environmental impact of mobility associated with the use of SMARTMOOV' [1]	29	SMARTMOOV' has helped me to reduce the environmental impact of my travels	6

[1] In the ex_ante survey there were three questions assessing the Smartmoov' influence on limiting travel environment impacts. The three questions showed an excellent alpha of Cronbach's Alpha (α=.911) and with their mean value was produced a new variable.

It is possible to identify that the expected outcomes were valued more, compared to the actual reported outcomes. Table 8 presents the statistical significances of these differences.

Table 8 – Expectations and revealed behaviour: Statistical differences between ex-ante and ex-post

Expected and actual outcomes	**Paired T-test**	**p-value**	**Wilcoxon Test**	**p-value**
SMARTMOOV' as a facilitator towards a mobility behaviour change	3.64	<.001*	-5.347	<.001*
SMARTMOOV' as an incentive to change mobility behaviour	9.117	<.001*	-3.20	<.001*
Gain time, thanks to SMARTMOOV'	6.84	<.001*	-4.893,	<.001
SMARTMOOV' as a tool that helps to reduce the environmental impact of travels	8.42	<.001*	-5,374	<.001*

* significant at the 0.01 level

For all the outcomes studied there are significant mean differences, decreasing the appreciation between the ex-ante and ex-post surveys. Thus, after the test people do not think that Smartmoov' is a real facilitator towards a change of travellers' behaviour, the mean value passed from neutral (*M*=3.35, *SD*=.849) to disagree (*M*=1.98, *SD*=1.022). After the Smartmoov' test the participants disagree that this app is an incentive to change their behaviour, the mean value passed from neutral (*M*=3.35, *SD*=.849) to disagree (*M*=1.98, *SD*=1.022). The real gain of time using the Smartmoov' did not match the expectations of the participants, the mean value passed from agree (*M*=4.42, *SD*=.581) to neutral (*M*=2.61, *SD*=1.355). Finally, Smartmoov' app didn't help to decrease their environmental impacts, passing from an agreement perspective on the ex_ante (*M*=3.76, *SD*=1.046) to a disagreement on the ex_post (*M*=2.20, *SD*=1.276).

Traveller intentions

Table 9 summarizes the participants' agreement (those answered 4 and 5 to the likert scale) as regards their intentions towards their travel behaviour declared in the ex_ante and ex_post questionnaires.

Table 9 – Participants who agreed with theintention statements

Agreed that...	ex-ante survey	ex_post survey
I intend to change my travel habits	8	3
I would use the Public Transport more often if I had real-time information on timetables and passes	24	16
I would use Vélo'v (Bike-sharing) more often if I had real-time information on the availability of Vélo'v (Bike-sharing) and occupation sites	13	10
I would use my car more often if I had real-time traffic information	16	4
I would carpool more often if I had real-time information on the its availability	18	14

The number of participants agreeing with the statements decreased from ex-ante to the ex-post survey. Table 10 shows the statistical significance of these differences.

Table 10 – Intention statements: Statistical difference between ex-ante and ex-post

Statements	Paired T-test	p-value	Wilcoxon Test	p-value
I intend to change my travel habits	2.003	.051	1.86	.068
I would use the Public transport more often if I had real-time information on timetables and passes	1.772	.083	-1.741	.082
I would use Vélo'v (Bike-sharing) more often if I had real-time information on the availability of Vélo'v (Bike-sharing) and occupation sites	N/A	N/A	-1.741	.082
I would use my car more often if I had real-time traffic information	N/A	N/A	-2.546	.011*
I would carpool more often if I had real-time information on the its availability	N/A	N/A	-1.210	.226

* significant at the 0.05 level.

In table 10 it can be observed that the only significant statistical difference was related to the use of car thanks to the real time information. In fact, the number of participants who agreed using more the car strongly decreased from 16 (ex-ante) to 4 (ex-post).

Effects on travel behaviour

Regarding the most frequent travel, in general terms, no global changes towards sustainable mobility occurred. In fact, some participants moved from car to other modes and other participants from more sustainable modes to car. In contradiction with the theoretical expectations, the number of people using polluting modes has slightly increased after the test (Table 11).

Table 11 – Most frequent mode use: differences between ex-ante and ex-post by seasons

	SEASON			
	Autumn/Winter		Spring/Summer	
MODE	Ex-ante	Ex-post	Ex-ante	Ex-post
Car	23	24	16	17
Public Transport (PT)	15	15	11	9
Bicycle	0	1	5	6
Walk	3	2	5	4
Motorcycle	0	2	2	3
PT + soft modes	5	1	3	2
PT + Car	0	1	3	6

Table 12 summarises the statistical differences between the ex-ante and ex-post questionnaires as regards the use of transport modes in Autumn/Winter, Spring/Summer and weekends. It is possible to state that the introduction of the Smartmoov' did not produced any change in the use of car, motorcycles, bicycles and Velov'v (bike-sharing).

Table 12 - Use of the transport modes in the different periods: statistical difference between ex-ante and ex-post

Mode	Car		Motorcycle		Bicycle		Velov'v	
used in…	Wilcoxon Test	p-value	Wilcoxon Test	p-value	Wilcoxon Test	p-value	Wilcoxon Test	p-value
Autumn/Winter	.426	.670	-1.187	.235	1.218	.223	1.000	.317
Spring/Summer	-.610	.542	-.115	.909	-.182	.856	-.182	.856
Weekends	-.832	.405	-.816	.414	-.110	.912	-.707	.480

Even more, when comparing the use of the PT for the Autumn/Winter and Spring/Summer season it is observed that the introduction of the Smartmoov' did not produced any change in the use of this mode. Nevertheless, during weekends the answer before and after shows significant, but weak difference of the medians (Table 13). Comparing the walking, between ex-ante and ex-post questionnaires, during the Autumn/Winter and Spring/Summer significant changes of the medians were observed. During the weekends the test did not revealed significant differences (Table 13). More people used this mode after the test (1, 2, 3 and 4 times a week) and the “never” score decreased. However, it is not possible to assume that these changes are entirely related to the introduction of the app.

Table 13 – Use of the transport modes (PT and walking) in the different periods: statistical difference between ex-ante and ex-post

Mode	PT		Walking	
used on…	Wilcoxon Test	p-value	Wilcoxon Test	p-value
Winter/Autumn	-1.604	.109	2.543	.011*
Spring/Summer	-1.342	.180	-2.614	.009*
Weekends	-2.194	.028*	-.818	.413

* significant at the 0.05 level.

Smartmoov’ Use

Table 14 shows that the number of people who said using Smartmoov’ to plan their trips after the test was substantially lower than those expressed the intention of using it before.

In fact, the use of Smartmoov’ to plan occasional and daily trips showed significant changes after the test, decreasing in both cases ($Z=-4.564$, $p<.001$ for occasional trips; $Z=-4.347$, $p<.001$ for daily trips).

Table 14 – Participants who agreed to use Smartmoov’

Participants claim that…	N	Participants report that…	N
Intend to use SMARTMOOV’ to plan occasional trips	45	Used SMARTMOOV 'plan for occasional trips	28
Intend to use SMARTMOOV’ to plan daily commute	39	Used SMARTMOOV' to plan my daily commute	21
		Used SMARTMOOV’ daily	12

The statement: “I used Smartmoov’ daily” was provided in the ex-post questionnaire to better understand the use of the Smartmoov’ on the daily base. The answers show a neutral opinion ($M=2.89$, $SD=1.080$), with 17 people disagreeing, 17 neutral and 12 agreeing.

The three decision-making scenarios, Pre-trip planning, En-Route and Re-route, were tested in the ex-post survey and 15 people stated that they used Smartmoov’ for pre-trip planning and 10 for en-route information, while 20 got re-route information.

Another aspect analysed in the ex-post questionnaire was the usefulness of Smartmoov’ in discovering new routes. The mean answers show a neutral outlook ($M=2.93$, $SD=1.526$) but 16 participants reported that they found new routes using Smartmoov’. Furthermore, 14 participants stated that Smartmoov’ allowed them to save time during their travels; 11 of them agreed on both cases. Finding new routes and saving time during the travel thanks to Smartmoov’ are significantly and positively correlated ($r_s = .652$, $p<.001$).

Willingness to pay

An important issue to understand the potential success of Smartmoov’ is to assess the willingness to pay after the test. Figure 2 shows that the willingness to pay after the test is significantly lower than previously (Z=-2.062, p = .039). The median score rating has decreased from disagree scale point (2.0) to totally disagree scale point (1.0).

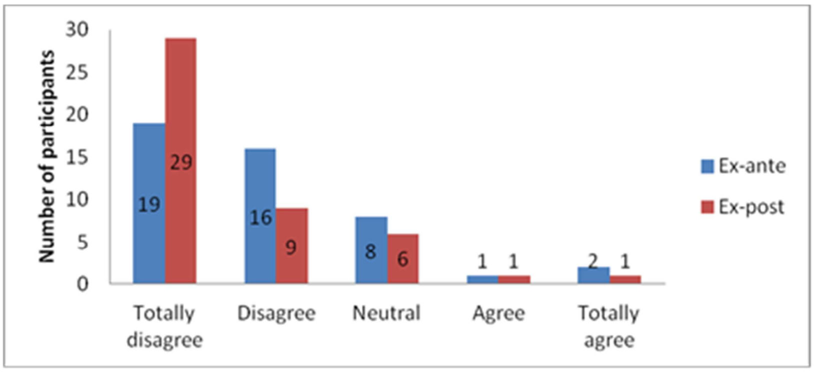

Figure 2 – Willingness to pay for Smartmoov'

Ergonomics

The ergonomics of Smartmoov' was evaluated through three statements. Table 15 reports the differences of the level of agreement between ex-ante and ex-post (easiness to use: Z=-4.682, p <.001; facing problems: Z=-3.062, p=.002). It is possible to observe that all the values are lower after the test, meaning that people faced more difficulties than expected using Smartmoov' .

Table 15 – Participants who agreed with ergonomic statements

Participants claim that...	N	**Participants report that...**	N
Expect to have an easy to use app	38	SMARTMOOV' is an easy to use app	14
Don't think that will face different problems using SMARTMOOV' daily	15	Didn't faced different problems using SMARTMOOV 'daily	7
		Did not lost time using SMARTMOOV'	21

The statement "I did not lost a lot of time using Smartmoov'", was only present in the ex-post questionnaire. 21 participants agreed that they did not lost time using Smartmoov' and only 10 admitted that they lost time using such an app.

Theory of planned behaviour constructs modifications after test

Before the test, a principal component analysis (PCA), using the statements on the ex-ante questionnaire, was used to identify the TPB constructs: attitudes towards behaviour (ATT), the perceived behaviour control (PCB) and the subjective norm (SN). The same statements were used in the ex-post questionnaire and the Cronbach's α was computed for the items used for each factor, to understand if this constructs still made sense for the sample of 46 participants. ATT (α=.671) and PCB (α=.674) constructs in the ex-post did not reach the threshold, but showed an acceptable value for internal consistency (Cortina, 1993). SN (α=.745) showed a good internal consistency. Participants' scores on reliable scales were computed by taking their mean on items included in each scale, so that scores ranged from 1 to 5. Pair T-test and Wilcoxon Signed Ranks test were preformed to verify if there were significant differences on how participants scored the TPB constructs between the two questionnaires (Table 16).

Table 16 – TPB constructs: Statistical difference between ex-ante and ex-post

Construct	ex_ante survey		ex_post survey		Pair T-test	*p*	Wilcoxon Test	*p*
	Mean	SD	Mean	SD				
ATT	3.00	1.234	2.99	1.213	1.518	.136	-.500	.617
PBC	2.98	1.197	2.71	1.162	.068	.946	-1.315	.188
SN	2.82	.957	1.48	.673	N/A	N/A	-5.879	<001*

* significant at the 0.01 level

ATT and PBC showed no significant differences between questionnaires, remaining stable over the two questionnaires' period. On the contrary, SN construct presented a significant decrease between ex-ante survey (2.75) and ex-post survey (1.25).

DISCUSSION AND CONCLUSIONS

No strong constraint on the use of Smartmoov' was recorded, being the participants familiar with the technology and with the use of Smartphones applications (e.g. google maps), GPS navigators and websites for getting travel information.

With the goal to assess the effects that Smartmoov' had on the mobility of the participants, the data before and after test were compared. In this study it is possible to recognise that this app alone had no influence on the modal shift; The expectations about Smartmoov' were higher than they experienced during its use.

The participants were hesitating about the potential of the app to facilitate or boost the modal shift; after the test the participants disagreed that this app is able to induce modal diversion.

The real time feature of Smartmoov' did not match the expectations of the participants; 42 people wanted to save time and only 14 actually did it. The willingness to pay for its use has also decreased after the test. These results show a relationship between the time saving allowed by Smartmoov' and the willingness to pay, to be considered for the economic success of this app.

In the city of Stockholm, the introduction of a co-modal application helped the participants to achieve a more sustainable mobility through a greater use of public transport and a reduction of car use (Skoglund and Karlsson, 2012). With the introduction of Smartmoov' in Lyon, the opposite was observed: an increase of the polluting modes used for the most frequent travels (3 people more in Autumn/Winter and 2 people more in Spring/Summer) was recorded while the total amount (all modes) of travels remained unchanged after the test. The stability of the modes used shows how past travel choices influenced the future ones, allowing to predict the modal choice.

The potential of this app to promote a sustainable mobility is quite questionable: the participants stated that this app did not help them to reduce their environmental impact as much as they wanted. In addition, the intention to use more sustainable modes (PT, bike sharing, carpooling) if real-time information is available decreased after the test.

At the onset of the test, travellers' evaluation towards the travel planner was slightly positive, but this waned over time while the use of the different modes remained stable after the test, albeit a small increase of the car for the most frequent trip was observed. This negative evaluation of Smartmoov' after the test can be due, partly, to the application itself as it was not easy-to-use during the daily commuting. In fact, Fayish and Jovanis (2004) had already observed that, to induce the use of ATIS, travellers ask that the systems are user-friendly, providing accurate information and an enjoyable graphical design. This evaluation showed that Smartmoov' did not meet yet all the technical preconditions demanded by the travellers for inducing a change on mobility behaviour.

However, after the test, the results were in line with previous studies, meaning that few people used this app on a daily basis or for planning daily commuting, while it was most often used to plan occasional travels (Bonsall and Joint, 1991; Grotenhuis et al., 2007).

The expert group on Urban ITS (2001) concluded that the implementation of the Multimodal information system was the most economical method to get a reduction of 24 000 tons of CO_2/year in Lyon, equivalent to 1% of modal shift from cars to bikes and/or public transport. The results of this research wonders about the capacity of these systems, alone, to get 1% of modal shift. These systems have to be part of a wider strategy to achieve sustainable urban mobility, which includes more investments on public transport, on pedestrian/bicycle paths and measures to reduce the car use.

It was possible to identify that, in this case, the model proposed by the Theory of Planned Behaviour (TPB) was not able to predict the intentions towards the modal shift. In fact, the intentions to change mode slightly came from the personal evaluation of performing the modal shift (attitude towards behaviour, ATT); the other two constructs, subjective norm (SN) and perceived behavioural control (PBC), did not play a role in explaining intentions.

The ATT, PBC as well as intentions did not change significantly. The stability of intentions and of perceived behavioural control could explain the observed behaviour stability. Those factors presumably determined the behaviour in the past and, as it remained unchanged, produced the corresponding behaviour in the future (Bamberg et al., 2003). This observed lack of fit of the TPB can be the effect of the participants' high frequency of past behaviour, which leads to mobility habits, which strongly influence the process of modal choice. This finding means that the behaviour under consideration, rather than being completely reasoned, is partly under the direct control of the stimulus situation, which is, repeating the habitudinal performance (Bamberg et al., 2003).

Aarts et al. (1997) found that systematic travels limit the effects that information can have on modal diversion because people automatically behave without consulting the available information. Nevertheless the routine, the human social behaviour is always regulated at a certain (even if low) level of cognitive effort. Therefore, for achieving a multimodal behaviour, it is essential that the use of information contributes to the disruption of the routine behaviour and initiates reasoned action (Kenyon and Lyons, 2003).

Mobility habits are a constraint in the process of modal choice. The information can play a role in the modal diversion only if is able to be meaningful enough to give to users significant reasons to break their routine, changing the cognitive foundation of intentions and behaviour.

The conclusions of this study should be considered with care due to the sample size (n_{ex_ante} = 50; n_{ex_post} = 46) and, thus, it is not possible to generalise the conclusions. Furthermore, when comparing the results before and after the test, it was impossible to have a control group since all participants got a Smartphone. This limitation is not uncommon in field studies, but it raises the possibility that events other than the introduction of the multimodal app may have produced the observed effects (Bamberg et al., 2003).

Finally, during the test, the Smartmoov' app was updated three times, adding small changes in terms of content and user interface that could cause some bias on the results.

Nevertheless, this research provides added value as regards the impacts that ATIS can have on mobility and can be a starting point for future studies.

Even though Multimodal traveller information systems are a recent concept, and nowadays used globally. Therefore there is a real need for the assessment of their impacts because many funds are being addressed towards their development, without a real understanding of its effectiveness.

In this research the TPB model was applied to predict the modal shift when using real time information. It can be concluded that, with the available data, this model did not fit the behaviour. Thus, it is proposed to apply this theory to a larger sample using the findings of this research for the factor constructions. Afterwards, it would be of utmost importance to test other behavioural models to understand if they work better to predict the modal shift, in case of multimodal real time information. A mix of models or a new model could be, eventually, constructed to describe and predict this complex behaviour.

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