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6 **CAN THE MULTIMODAL REAL TIME INFORMATION SYSTEMS INDUCE A**
7 **MORE SUSTAINABLE MOBILITY ?**
8

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1 **ABSTRACT**

2
3 Modern cities show an increasing interest in Advanced Traveller Information Systems (ATIS),
4 with a growing attention to real time multimodal information. Through those systems, decision
5 makers hope to achieve a shift from the car to alternative, environment-friendly modes of travel.
6 Unfortunately, few comprehensive assessments have been undertaken in order to verify the
7 actual contribution of ATIS to such modal shift.

8 This paper aims at assessing the effects on travel behaviour of Optimod’Lyon, a multimodal real-
9 time information navigator for smartphone, developed in Lyon in 2013 and launched in May
10 2015. To this end, a quali-quantitative approach was adopted, administering a questionnaire and
11 organising focus groups before and after the test of the application. A stratified sample of 50
12 people living in the metropolitan area of Lyon was, likewise, involved. The Theory of Planned
13 Behaviour was used as the theoretical framework for the questionnaire design, investigating
14 attitudes, subjective norms and perceived behavioural control. To evaluate the behavioural
15 change, data were analysed using parametric and non-parametric tests, factor analysis and binary
16 logistic regression.

17 Survey participants were initially interested on the Optimod’Lyon and showed a positive attitude
18 towards its use. Prior to the test, they evaluated positively the travel planner , but this lessened
19 over time and, after the test, the use of the different travel modes remained stable, showing a
20 consistency on the most used mode, on behavioural patterns and attitudes, strongly related to
21 habits and to the frequency of the past behaviour.
22

1. INTRODUCTION

Transport of goods and people is an important driver of the global economic growth and prosperity fostering trading and people accessibility and connectivity. In the year 2012, the transport sector in Europe was responsible for 31.8% of the final energy consumption and 1,173.3 million tonnes of CO₂ equivalent of greenhouse gases, and a continuous escalation of these figures is envisaged (1). One favoured solution to offset such unsustainable trend is based on Advance Traveller Information Systems (ATIS) . ATIS are data integration systems delivering accurate, reliable, and timely information to travellers (2), helping them to plan their route, to estimate their travel time, and to make informed decisions using real-time information (3).

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.

The impact and effectiveness of ATIS critically depend on traveller's responses to these systems, on the typology of supplied information and on the way they are used by those travellers. Abdel-Aty (2002) (4) stated that it is not easy to define and quantify ATIS impacts due to the lack of actual situations in which travellers' behaviour can be observed under the influence of ATIS. The potential of ATIS to affect mobility behaviour has hitherto rarely been researched (5,6). However, there have been many attempts to assess ATIS benefits gathering data from various sources, predominantly from surveys but also from field observations and simulations (7). Most of the surveys concerned the effects of traffic information on car drivers, mainly commuters, to estimate user satisfaction and the effects of ATIS operation (8,9,6). Arguably, only few studies have explored the consequences of information on public transport (PT) ridership, notwithstanding its potential role in increasing it and improving customer satisfaction (10,11). The effects of multimodal real time navigators are even less analysed. In fact, while the multimodal journey planners are increasingly important, real time navigators and research about their effect on travel behaviour are still in their infancy. The project Optimod'Lyon (2012-2015) was pioneer in developing a real time navigator for smartphone, including all transport modes (car, public transport, bike, bike sharing, foot, car sharing and car pooling) in an integrated way, and this paper presents the results of the test on a panel of users.

Real-time information is the novelty introduced by Smart-Way, one of the first smartphone applications for PT when it was developed in 2010-2011 while, today, more real-time applications, as those developed for Zurich, Vienna, London (11) are available. However, an application to allow reaching a destination through a multimodal trip chain suggested on the basis of real time information did not exist before the development of Optimod'Lyon, followed up by the EU project Opticities, developing a similar app also in Torino, Gothenburg and Madrid (www.opticities.org).

Information is a key factor in today's' mobility, having a high potential for optimising the travellers' choice. Abdel-Aty (2002) (4) noted that accurate and high quality information are decisive for using public transport.

If systems like these have an effect on modal choice, and how it happens, highly depends on the way they are utilised by users. Obviously, this is not only a technological but also a social process which requires technology assessment (5). Farag and Lyons (2012) (12) showed how travel behaviour, travel attitudes and socio-demographic features have the strongest effect on

1 pre-trip PT information use both for business and leisure trips. It was also argued that past
2 behaviour and habits are not always a good predictor of future behaviour (13).

3 Complex human behaviour is cognitively regulated and, despite existing bye-laws, it
4 should be subjected to at least some degree of monitoring. As a consequence, the new
5 information provided by ATIS, if relevant and convincing, could produce changes in attitudes,
6 subjective norms and perceptions of behavioural control, affecting intentions and likely to
7 influence subsequent behaviour (13).

8 The objective of this research is, thence, to bridge the gap of knowledge in the existing
9 literature by analysing the effects on travel behaviour of the real-time multimodal information
10 provided by the smartphone application developed within the research project Optimod'Lyon.
11 This paper aims at assessing the effectiveness of multimodal real-time information systems,
12 pointing out the limitations before their use and recording the changes induced on travel
13 behaviour.

14 The next section describes the methodology for data collection and analysis. The results
15 are presented in section 3 while section 4 discusses those results and compares them with the
16 relevant literature.

17 **2. METHODOLOGY: THE SURVEY AND THE DATA ANALYSIS**

18 The Lyon Metropolitan Area, under the Grand Lyon authority, covers an area of 512 km² (58
19 municipalities) with a population of about 1.3 million people. Lyon is an important centre of
20 economic development and it is the second French metropolitan area after Paris.

21 Participants to the survey were selected according to a stratified sampling plan based on
22 gender; age; education; occupation; income; presence of children in the household; travel pattern
23 (travel time, scope, used mode, origin and destination). A sample size of 50 people was recruited
24 by a specialised agency following the defined sampling plan. The sample was not designed to
25 represent the local or national population, but to include different users' profiles so as to better
26 test all possible behaviours and reactions to the use of application.

27 The survey administered to the sample followed a quali-quantitative approach based on
28 two tools: the web-questionnaire and the focus group that were meant to work in an integrated
29 way.

30 The web-questionnaire, created with the Google form platform, was addressed to the
31 participants in two stages: in February 2013 (ex-ante) and, five months after testing the
32 application (from June to October), in October 2013 (ex-post). Just few days after the
33 administration of the ex-ante questionnaire the focus groups were organised to investigate the
34 issues contained in the questionnaire, thus allowing both a cross-reference with the topics
35 discussed and a double check of the results of the questionnaire. All the 50 individuals
36 participated in the first stage, while 4 dropped the survey and did not participate in the second
37 stage. During the test of the application, an on-going survey was undertaken to check its
38 functionalities. To properly involve the panel throughout the survey period, a smartphone
39 (Samsung Galaxy S3 mini) was presented as incentive.

40 The ex-ante and ex-post questionnaires consisted of five sections: travel habits, attitudes
41 towards mobility, environmental issues, familiarity with, and interest on the technological tools,
42 and Optimod'Lyon application. The focus group followed a similar pattern, investigating the
43

1 personality traits, attitude towards technology, perception about real time information,
2 expectations about Optimod' Lyon application, willingness to pay and barriers for using the app.

3 In designing the questionnaire and the focus group, attention was paid to attitudes and
4 behaviours related to the most frequent trip made by respondents, disregarding purpose and
5 people occupation (workers, students, retired people, housewives, etc.). The most frequent trip is,
6 arguably, the best known for users in terms of time and general constraints. The most frequent
7 trip could induce a specific mobility behaviour, regardless of people characteristics
8 (employed/unemployed) and trip purpose (work, shopping, etc.): it is more related to people
9 habits, and , hence, less likely to be changed (14). The theory underpinning the survey design is
10 that of planned behaviour (TPB), largely applied to understand the link between intention and
11 behaviour, which has shown positive results in many fields, thus becoming a powerful predictive
12 model for explaining human reactions (15). The questions regarding several issues (travel
13 behaviour of users, their opinions about private and public transport and about technological
14 tools, etc.), were rated according to a five point Likert scale, as this represented a good
15 compromise in terms of overload for the respondent (16). That scale was chosen for consistency
16 throughout the questionnaire as well as to avoid reporting errors (17).

17 Since the total number of participants was 50, it was not possible to use the central limit
18 theorem neither the Shapiro-Wilk test to guarantee the normal distribution of the variables.
19 Assuming that data would never be precisely normally distributed, according to Brown (2011)
20 (18) and Fife-Schaw (2013) (19) we considered the variables relatively normal if Skewness and
21 Kurtosis values ranged from -1.5 and +1.5. Descriptive analysis, parametric and non-parametric
22 tests, factor analysis and binary logistic regression were used as statistical approaches to analyse
23 the collected data and to assess the effectiveness of the application. The BMDP Statistics
24 Software (20) was used for these analyses.

25 To identify the TPB factors structure, a principal component analysis with quartimax
26 rotation was conducted on 10 questionnaire items. For samples with less than 60 participants,
27 items can only be acceptable if communalities mount at least to 0.60 (21). Therefore, two items
28 were removed in the first analysis. In the second analysis, sampling adequacy (Kaiser-Meyer-
29 Olkin) indicated a mediocre compact of correlations (0.608) and the analysis of sphericity
30 displayed a strong relationship between the items (df=28, p<0.001), both of which showed that
31 factor analysis is appropriate for this measure. Factors were extracted on the basis of eigenvalue
32 greater than 1, percentage of variance accounted, percentage of variance explained by each
33 factor, number of items with significant factor loadings and factor interpretability (22).

34 35 **3. RESULTS**

36 Participants are evenly gender-balanced (25 women and 25 men), their ages ranging from 23 to
37 68. As for education, 32% hold a university degree while 68% have not attended university and
38 two of them (4%) have no diploma.

39 34% have an average gross household income of 3,000-5,000 €/month, while 48% earn
40 1,500-3,000 €/month; only 8% get less than 1,500 €/month. As regards household composition.
41 38% live as a couple; 22% live alone and 28% have a larger family (≤ 4 people). People living
42 with children represent 44% of the sample.

43 Almost all respondents have a driving license (90%) and the overall car availability of
44 their households is rather high: 44% own one car while 42% own two cars. However, 10% do
45 not have access to any car within the household.

1 Analysing travel habits – daily travels and most frequent trip – the most favoured mode is
2 the car as driver (52% in autumn-winter, 36% in spring-summer), while 32% use public
3 transport, showing a strong decrease in the summer time. 10% of respondents declare to use soft
4 modes in connection with public transport. Since most of the participants are part of the
5 employed population, for 74% of them the most frequent trip is to work, while 5 participants
6 travel for leisure and 4 to pick up somebody.

7 This paper focuses on the quantitative analysis, presenting only the results of the
8 questionnaires, which are actually confirmed by the focus groups outcomes. In the next two
9 sections the results referred to the ex-ante and ex-post stages of the tests are presented: the first
10 section shows the potential barriers for using the app and evaluates the constructs of the TPB.
11 The second section presents the effects of the app on travel behaviour, comparing the answers
12 provided by the panel to the two-stage questionnaire.

13 14 **3.1 Ex-ante results: barriers to use and behavioural constructs**

15 The majority of the participants owned a smartphone (41 out of 50) and they acknowledged to
16 be skilled users of technology, showing a high level of interest towards technological devices.
17 When choosing a route to an occasional place, they mainly used web sites (e.g. Mappy or Via
18 Michelin) to get the information (44); the second most used tool is the GPS navigator (31), the
19 third one being apps like Google maps (28).

20 More than half of the participants (27) considered that apps help them in their daily life,
21 and found (31) that some apps are enjoyable to use. As for the willingness to discover new apps,
22 22 persons liked to do it.

23 The principal component analysis (PCA) allowed finding out three main factors,
24 matching the theory of planned behaviour. Table 1 shows the rotated matrix and includes all
25 loadings >0.30 , highlighting in bold the loadings of the items used to identify each factor.
26 Factors were identified as representing attitudes towards the behaviour (ATT), perceived
27 behavioural control (PBC) and subjective norms (SN). The number of factors was chosen
28 through the scree test, jointly used with the Kaiser criterion of computing the eigenvalues for the
29 correlation matrix, to avoid possible distortions in the results (23). The three factors explained a
30 total of 72.422% of the variability of the original eight variables. Parallel analysis was also used
31 to check if the number of factors for this number of observations was significantly different from
32 a parallel random process (24), confirming the number of latent constructs. Therefore, the
33 complexity of the data set can be considerably reduced by using these components, with
34 27.578% loss of information.

35 The value of mean communality was 0.724, greater than the threshold (0.70), and all
36 items presented a loading factor above 0.60 (25). The high loadings on two different items
37 related to both PBC and ATT made the factors meaningful and well matching the theory even
38 though loaded by only two variables.

39 Cronbach's α was computed for the items used in identifying each factor (SN, $\alpha = 0.802$;
40 ATT, $\alpha = 0.739$; PBC, $\alpha = 0.532$) and all values complied with the threshold (0.70) except the
41 PBC. Despite the PBC construct showed a poor value for internal consistency – even though still
42 acceptable – it was decided to use the PBC construct in the analysis because small samples size
43 can deflate the Cronbach's α value (26). Respondents' scores on the scales were calculated

1 considering the mean value on items in each scale (from 1 to 5). For all TPB constructs, the
 2 mean values of the 50 participants scored near the middle point of the scale (3). Pearson
 3 correlation and Spearman's rho did not show any significant correlation among the three
 4 constructs, so that they are independent.

5
 6 **TABLE 1 Rotated Principal Components Analysis (PCA) Structure Matrix**

Items	TPB	SN	ATT	PBC
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 Optimod'Lyon	SN	.762		
I expect that policy makers incite me use Optimod'Lyon	SN	.754		
I expect that policy makers put me under pressure to limit the environmental impacts of my travels	SN	.753		.346
I don't like driving for most frequent trip	ATT		.883	
I don't like travelling by car	ATT		.882	
I would use the Public Transport more often if I had real-time information	PBC			.809
I would use more the Vélo'v (bike-sharing) if real-time information was available	PBC			.784
Eigenvalues		2.713	1.795	1.286
Percentage variance explained		33.908	22.436	16.078

7 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
 8 = subjective norms; ATT = attitudes towards the behaviour; PBC = perceived behavioural control.

9 A 1 to 5 scale was used to inquire about the intention to change transport mode, 1 and 2
 10 expressing of the least willingness to change travel behaviour while 4 and 5 show the opposite.
 11 People responding (3) were considered undecided and, thus, left out.. Table 2 shows descriptive
 12 statistics for people who expressed the intention to keep or change their travel behaviour
 13 (hereafter, *keepers* and *changers*). The higher value showed by PBC *changers* is consistent with
 14 the theory as well as the lower value regarding the ATT.

15
 16 **TABLE 2 Descriptive statistics for TPB variables for different intentions**

Intention	Constructs	Mean	Min	Max	SD	Variance	n
Keeping travel behaviour (12 using car and 15 PT+soft modes)	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
Changing travel behaviour (6 using car and 3 using PT+soft modes)	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

17
 18 Mann-Whitney tests did not show significant differences between *keepers* and *changers*
 19 about SN (U=121, p=.985) and PBC (U=82.5, p=.149), but significant differences (p<.05) are

1 recorded for ATT (U=56, p=0.016). Thus, it can be argued that the *keepers* are the majority, both
 2 using the car and the sustainable modes, showing the strong influence of habits on daily travels.

3 Spearman’s rho (ρ) correlations among variables were calculated, and the three constructs
 4 did not show any significant correlation, meaning that multicollinearity would not be a problem
 5 in regressions using these variables as predictors (21).

6 A logistic regression was used to understand the ability of the TPB model to explain the
 7 modal change intention. SN, ATT and PBC were entered simultaneously in the regression where
 8 ATT and PBC constructs were significant (p<0.05) and SN construct was not. Then, a model
 9 using forward stepwise method was built. ATT were added to the model (Table 3). SN were
 10 excluded at the first step because they had significance values larger than 0.05. Finally, even
 11 though PBC had a significant value, it was left out on the last step because it did not contribute to
 12 better fit the model. For a logistic model, when the intercept is zero, the logit (or log odds) is
 13 zero, implying that the event probability is 0.5. This is a very strong assumption that sometimes
 14 is reasonable, but more often it is not. Therefore, a highly significant intercept in this model is
 15 generally not a problem (27).

16
 17 **TABLE 3 TPB 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

18 * sig. at .05

19
 20 As a further check, the backward stepwise method was used, not changing the above
 21 results, making confident about the reliability of the model. The Hosmer-Lemeshow and the C.C.
 22 Brown test report that the model adequately fits the data, since the values are higher than 0.05.

23 The model is reported in the equation (1):

$$24 \text{Pr[Maintain]} = \frac{e^{-1.068+.835\text{ATT}}}{1+ e^{-1.068+.835\text{ATT}}} \quad (1)$$

25 where the odds of maintaining the used mode increase by a multiplicative factor of 2.31 (Exp(a)
 26 = .835)) for each absolute increment of the ATT score. Globally, 80.6% of the cases are correctly
 27 classified.

28
 29 **3.2 Evaluation of the effects of the application on travel behaviour**

30 As argued in the methodological section, the analysis carried out after the test involved 46
 31 persons (four participants left the experiment). However, the figures of the initial sample have
 32 been retained.

33 Comparing the stated and revealed potential benefits of the application as declared by the
 34 individuals, it is possible to observe that the number of people with a positive view decreased in
 35 a statistically significant way from the ex-ante to ex-post survey. Likewise, the intentions to
 36 change their travel behaviour as a result of the application significantly differed between the two
 37 surveys (Table 4).

1 Table 4 shows that the only significant statistical difference was related to the use of car
 2 thanks to the real time information: the number of participants who admitted using more the car
 3 strongly decreased from 16 (ex-ante) to 4 (ex-post).

4
 5 **TABLE 4 Stated and revealed benefits and intentions: statistical differences between ex-**
 6 **ante and ex-post survey**

Stated and revealed benefits	Ex-ante (n° of people who agreed to the statement)	Ex-post (n° of people who agreed to the statement)	Paired T-test	p-value	Wilcoxon Test	p-value
Optimod'Lyon as a facilitator towards a mobility behaviour change	19	3	3.64	<.001*	-5.347	<.001*
Optimod'Lyon as an incentive to change mobility behaviour	17	9	9.117	<.001*	-3.20	<.001*
Gain time, thanks to Optimod'Lyon**	42	14	6.84	<.001*	-4.893,	<.001
Optimod'Lyon as a tool that helps to reduce the environmental impact of travels	29	6	8.42	<.001*	-5,374	<.001*
I intend to change my travel habits	8	3	2.003	.051	1.86	.068
I would use the Public transport more often if I had real-time information on timetables and passes	24	16	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	13	10	N/A	N/A	-1.741	.082
I would use my car more often if I had real-time traffic information	16	4	N/A	N/A	-2.546	.011*
I would carpool more often if I had real-time information on its availability	18	14	N/A	N/A	-1.210	.226

7 * significant at the 0.05 level.

8 ** In the ex-ante survey there were three questions assessing the Optimod'Lyon influence on limiting travel environment impacts.
 9 The three questions showed an excellent alpha of Cronbach's Alpha ($\alpha=.911$) and with their mean value was produced a new
 10 variable.

11
 12 Concerning the most frequent trip, an overall change towards a more sustainable mobility
 13 was not evident. In fact, some participants moved from car to other modes, while other
 14 participants switched from more sustainable modes to car. In contradiction with the theoretical
 15 expectations, the number of people using polluting modes has slightly increased after the test.
 16 The introduction of Optimod'Lyon did not produce any change in the use of car, motorcycles,
 17 bicycles and Vélo'v (bike-sharing) in autumn/winter, spring/summer or weekends.

18 The intention of using the app to plan occasional and daily trips showed significant

1 changes after the test, decreasing in both cases ($Z=-4.564$, $p<0.001$ for occasional trips; $Z=-$
2 4.347 , $p<0.001$ for daily trips).

3 The three decision-making scenarios – pre-trip planning, en-route and re-route – were
4 tested in the ex-post survey: 15 people used Optimod’Lyon for pre-trip planning, 10 for en-route
5 information, while 20 to get re-route information.

6 Another aspect analysed in the ex-post questionnaire was the usefulness of the app in
7 discovering new routes. Even though a neutral viewpoint is noticeable ($M=2.93$, $SD=1.526$), 16
8 participants reported that they found new routes using Optimod’Lyon. Furthermore, 14
9 participants stated that the app allowed them to spare time during their trips; 11 persons both
10 found new routes and saved time. Finding new routes and saving time during the travel thanks to
11 the app showed a significant and positive correlation ($r_s = 0.652$, $p<.001$).

12 An important issue to understand the potential success of Optimod’Lyon is to assess the
13 willingness to pay for using the application that, after the test, was significantly lower than
14 previously stated ($Z=-2.062$, $p = 0.039$).

15 The ergonomics of Optimod’Lyon was evaluated through three criteria: easiness to use,
16 problems using the app and time losses in searching information. There is a statistical difference
17 between ex-ante and ex-post survey (easiness to use: $Z=-4.682$, $p <0.001$; facing problems: $Z=-$
18 3.062 , $p=0.002$), showing that people faced more difficulties than expected using Optimod’Lyon.
19 The statement “I did not lose a lot of time using Optimod’Lyon”, was only present in the ex-post
20 questionnaire; while 21 participants agreed that they did not lose time using the application, 10
21 disagreed.

22 *3.2.1 Change of constructs of TPB after the test*

24 Before the test, a principal component analysis, using the statements from the ex-ante
25 questionnaire, was used to identify the TPB constructs: ATT, PBC and SN. The same statements
26 were used in the ex-post questionnaire and the Cronbach’s α was computed for the items used for
27 each factor, to understand if these constructs continued to be valid also after the test. ATT
28 ($\alpha=.671$) and PBC ($\alpha=.674$) constructs in the ex-post did not reach the threshold, but showed an
29 acceptable value for internal consistency (26). SN ($\alpha=.745$) showed a good internal consistency.
30 Participants’ scores on reliable scales were computed by taking their mean on items included in
31 each scale, so that scores ranged from 1 to 5. Pair T-test and Wilcoxon Signed Ranks test were
32 performed to verify if there were significant differences on how participants scored the TPB
33 constructs between the two questionnaires.

34 ATT and PBC did not show any significant difference between the two questionnaires; on
35 the contrary, SN construct presented a significant decrease between the ex-ante (2.75) and the
36 ex-post survey (1.25). These results further confirmed what found earlier about the lack of
37 predicting power of the TPB constructs and will be discussed in the next section.

38 **4 DISCUSSION AND CONCLUSIONS**

40 The results have showed there were no restraint in using Optimod’Lyon, as long as participants
41 are familiar with the technology and with the use of smartphones applications (e.g. Google
42 maps), GPS navigators and websites to obtain travel information. A sample including people of
43 different ages, education and profession showed how the use of technology largely cuts across

1 the socio-economic characteristics as proved by the wide market penetration of the ICT tools. In
2 fact, the rise in mobile devices popularity and the ubiquitous web are changing the way of living;
3 for example, social media have better performed than traditional systems in providing
4 information during emergency situations (28). 90% of American adults have a cell phone and
5 64% have a smartphone; mobile devices are full of sensors and such data can be harvested for
6 multiple uses¹.

7 Such a revolution, fostered by the ICT, has led decision makers to think that the
8 technological devices could also be the turning point in changing the travel behaviour,
9 encouraging the use of more sustainable transport modes thanks to a better information on them.

10 To this end the Optimod'Lyon project was funded to develop a so far inexistent tool ,
11 including in only one application all transport modes and giving real time intermodal routing
12 information. The panel selected for the test was monitored before, during and after the use of the
13 application to understand and assess its effects on the mobility patterns of the participants.

14 At the onset of the test, travellers' assessment towards the travel planner was slightly positive,
15 but this waned over time while the use of the different modes remained stable after the test, albeit
16 a small increase of the car for the most frequent trip was observed. 17 participants changed the
17 mode used for the most frequent trip, but their change was not driven by the search for a greater
18 sustainability (changing job location, finding of a better route, meteorological conditions).

19 This negative ex-post evaluation of Optimod'Lyon can be due, partly, to the application
20 itself as it was not easy-to-use during the daily commuting. Furthermore, during the test, the app
21 was updated three times, adding small changes in terms of content and user interface that could
22 cause some bias on the results. This evaluation showed that Optimod'Lyon did not meet yet all
23 the technical preconditions demanded by the travelers for inducing a change on mobility
24 behaviour. In fact, Fayish and Jovanis (2004) (29) had already observed that, in order to
25 encourage the use of ATIS, travelers request that the systems are user-friendly, providing
26 accurate information and pleasant graphical design.

27 In addition, after the test, the results were in line with previous studies, meaning that few
28 people used this app on a daily basis or for planning daily commuting, while it was most often
29 used to plan occasional trips (30,31).

30 The facts prove that the app alone had no influence on the modal shift and that the users'
31 expectations were higher as regards what they experienced during its use.

32 The reasons for such a mismatch are several; arguably, the real time feature of
33 Optimod'Lyon did not match the expectations of the participants: 42 people wanted to save time
34 and only 14 actually did it while ATIS should allow for time saving (31).

35 Moreover, there is the evidence that the information is not very effective for the daily trip
36 as the user is unlikely to consult it. Due to the strong habit in making such a trip, the information
37 becomes redundant over time. Skoglund and Karlsson (2012) (32), in a study carried out in
38 Stockholm, observed some changes in the respondents' assessment of the planner and the
39 provided service over nine months of the test. The planner was rated as less useful, less effective,
40 less amenable and less stimulating than initially expected. Those researchers also showed that the
41 information provided by the travel planner was relied upon, but the perceived value of the

¹ <http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/>

1 service dwindled over time. The service had been re-used by less than 40% of the respondents.

2 The willingness to pay for its use also lessened after the test, showing a relationship with
3 the lack of time saving allowed by the app. However, the lack of willingness to pay for such
4 applications is largely found in previous studies (33,34,11).

5 The expert group on Urban ITS (2011) (36) concluded that the implementation of the
6 Multimodal information system was the most economical method to get a reduction of 24,000
7 tons of CO₂/year in Lyon, equivalent to 1% of modal shift from cars to bikes and/or public
8 transport. The results of this research lead to mistrust the capacity of those systems, by
9 themselves, to get 1% of modal shift. Those systems have to be part of a wider strategy to
10 achieve sustainable urban mobility, including more investments on public transport, on
11 pedestrian/bicycle routes and measures to cut down on car use.

12 The participants stated that this app did not help them to reduce environmental impacts to
13 the extent they expected. However, notwithstanding the strong awareness of environmental
14 problems, a low intention to reduce car use is recorded (36) and is confirmed in our sample
15 where the intention to use more sustainable modes (PT, bike sharing, carpooling) if real-time
16 information is available decreased after the test, as also showed by the lack of fit of the TPB
17 model.

18 The intention is the best predictor of the future behaviour unless strong habits towards the
19 target behaviour prevail. However, if there is no intention to change travel habit, the use of a
20 journey planner does not bring any additional information, as confirmed by the literature:

- 21 - there is no correlation between the respondents' assessment of the travel planner and their
22 reported change of travel mode (e.g. more by public transport/less by car) as a consequence of
23 access to the travel planner (32);
- 24 - there is little evidence to suggest that the provision of information has been effective in
25 promoting modal shift (32);
- 26 - realising changes in people's travel behaviour is difficult (37). There are several co-operating
27 factors that determine how the individual perceives his/her 'action space' and the choices that
28 are considered possible. These factors include the design of the transport system but also the
29 household socio-economic situation, accessibility to services, as well as motives, attitudes,
30 knowledge and, not least, habit. Routine habits, such as commuter journeys, are most often
31 undertaken without further thought or reflection (13,38).

32 As the results of the test showed, the model proposed by the Theory of Planned
33 Behaviour (TPB) was unable to predict the intentions in regard to modal shift. In fact, the
34 intentions to change mode slightly came from the personal assessment of shifting modes
35 (attitude towards behaviour, ATT); the other two constructs, subjective norms (SN) and
36 perceived behavioural control (PBC), did not play a role in explaining intentions.

37 The ATT, PBC as well as intentions did not change significantly. The stability of
38 intentions and of perceived behavioural control could explain the observed behaviour stability.
39 Those factors presumably determined the behaviour in the past and, as this remained unchanged,
40 prompted the corresponding behaviour in the future (13). This observed lack of fit of the TPB
41 can be related to the participants' high frequency of past behaviour, which leads to mobility
42 habits, strongly influencing the process of modal choice. Hence, the behaviour under

1 consideration, rather than being completely reasoned, is partly under the direct control of the
2 stimulus situation, that is, the repetition of the habitual performance (13).

3 Aarts et al. (1997) (39) found that systematic travels limit the effects that information can
4 have on modal shift because people automatically behave without consulting the available
5 information. Disregarding routines, human social behaviour is always regulated at a certain (even
6 if low) level of cognitive effort. Therefore, for inducing a multimodal behaviour, the use of
7 information should contribute to disrupt the routine behaviour and to initiate reasoned action
8 (40).

9 Mobility habits are a constraint in the process of modal choice. The information can play
10 a role in shifting modes only if it becomes meaningful enough to provide users with significant
11 reasons to break away from their routine, thus changing the cognitive foundation of intentions
12 and behaviour.

13 Individuals most inclined to use Optimod'Lyon are middle aged car owners, with a high
14 educational level and familiar with technology. However, a motivated use of information through
15 the travel planners is a real challenge and, hence, unlikely to change the travel behaviour of
16 individuals unless some benefits are perceived. Actually, only three out of the eight persons
17 having declared their intention to change their behaviour before the test, have retained such
18 intention.

19 The conclusions of this study should be considered with caution due to the sample size
20 (ex-ante=50; ex-post=46); nevertheless they are confirmed by the results of the focus groups and
21 they match well the outcomes of other studies. Nevertheless, it is not possible to generalise these
22 conclusions as it was impossible to have a control group since all participants got a smartphone.
23 This limitation is not uncommon in field studies, but it raises the possibility that events other
24 than the introduction of the multimodal app may have produced the observed effects (13).

25 This research provides, nonetheless, added value as regards the impacts ATIS can have
26 on mobility and may be a starting point for future studies.

27 Even though multimodal traveller information systems are a rather recent concept – albeit
28 nowadays globally used – there is a real need for the assessment of their impacts as many funds
29 are being addressed towards their development, without a real understanding of their
30 effectiveness.

31 In this research the TPB model was applied to predict the modal shift when using real
32 time information. It can be concluded that, with the available data, this model did not fit the
33 expected behaviour. Thus, the research is continuing within the already mentioned Opticities
34 project, applying this theory to a larger sample and using the findings of this research for the
35 factor constructions. Thence, in the Opticities project, other behavioural models will be tested to
36 understand if they work better to predict the modal shift, in case of multimodal real time
37 information and a mix of models or a new model will be, eventually, constructed to describe and
38 predict this complex behaviour.

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1 REFERENCES

- 2 1. European Commission. *EU Transport in figures - Statistic Pocketbook 2014*. Publications
3 Office of the European Union, Luxembourg, 2014.
- 4 2. Hyejung H. *Measuring the Effectiveness of Advanced Traveler Information Systems*
5 *(ATIS)*. North Carolina State University, Raleigh, 2009.
- 6 3. Kumar, P., R. Dhanunjaya and S. Varun (2003), *Intelligent transport system using GIS*,
7 Proceedings of the Map India International Conference on GIS, GPS, Aerial
8 Photography, and Remote Sensing, New Delhi, 2003.
- 9 4. Abdel-Aty, M. *Design and Development of a Computer Simulation Experiment to*
10 *Support Mode/Route Choice Modeling in the Presence of ATIS*. Civil and Environmental
11 Engineering Department, University of Central Florida, Orlando, 2002.
- 12 5. Gotzenbrucker, G., and M. Kohl. *Sustainable Future Mobility by ICTs. The impacts of*
13 *Advance Traveler Information Systems on mobility behavior*. Proceedings of the 8th ITS
14 European Congress, Lyon, 2011, pp.1-15.
- 15 6. Chorus, C., E. E. Molin, and B. Van Wee. Use and Effects of Advanced Traveller
16 Information Services (ATIS): A Review of the Literature. *Transport Reviews*, Vol. 26(2),
17 2006, pp.127-149.
- 18 7. Williams, B. M., H. Hu, A. J. Khattak, N. M. Roupail, and P. Xiaohongand
19 *Effectiveness of Traveler Information Tools*. North Carolina State University, Raleigh,
20 2008.
- 21 8. Khattak, A. J., J.L. Schofer, and F.S. Koppelman. Commuters' en-route diversion and
22 return decisions: analysis and implications for advanced traveler information systems,
23 *Transport Research Board Part A*, Vol. 27(2), 1993, pp.101-111.
- 24 9. Hong Chen,g G. and S. Li Jun. The Advanced Traveler Information System for
25 Metropolitan Expressways in Shanghai', In *Transportation Research Record: Journal of*
26 *the Transportation Research Board*, No. 1944, Transportation Research Board of the
27 National Academies, Washington, D.C., 2006, pp.35-40.
- 28 10. Jou, R.C. Modeling the impact of pre-trip information on commuter departure time and
29 route choice. *Transportation Research Part B*, Vol.35(10), 2001, pp.887-902.
- 30 11. Pronello, C., and C. Camusso. User requirements for the design of efficient mobile
31 devices to navigate through public transport networks. In Thomopoulos N., Givoni M.,
32 Rietveld P. (Eds.). *ICT for transport: opportunities and threats*, NECTAR series on
33 Transportation and Communications Networks Research, Edward Elgar, Cheltenham,
34 2015, pp.55-93.
- 35 12. Farag, S., and G. Lyons. To use or not to use? An empirical study of pre-trip public
36 transport information for business and leisure trips and comparison with car travel.
37 *Transport Policy*, Vol. 20, 2012, pp.82-92.
- 38 13. Bamberg, S., I. Ajzen, and P. Schmidt. Choice of Travel Mode in the Theory of Planned
39 Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic and Applied*
40 *Social Psychology*, Vol. 25(3), 2003, pp.175-187.
- 41 14. Pronello C. and C. Camusso, Travellers' profiles definition using statistical multivariate
42 analysis of attitudinal variables, *Journal of Transport Geography*, Vol. 19(6), 2011
43 pp.1294-1308.

- 1 15. Ajzen, I. The Theory of Planned Behavior. *Organizational Behavior and Human*
2 *Decision Processes*, Vol. 50, 1991, pp.179-211.
- 3 16. Groves, R., F. Fowler, M. Couper, J. Lepkowski, E. Singer, and R. Tourangeau. *Survey*
4 *methodology*. John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
- 5 17. Wholey, J., H. Hartry and K. Newcomer. *Handbook of practical program evaluation*.
6 John Wiley & Sons, Inc., San Francisco, CA, 2004.
- 7 18. Brown, S. *Measures of Shape: Skewness and Kurtosis*. Tompkins Cortland Community
8 College, 2011. <http://www.tc3.edu/instruct/sbrown/stat/shape.htm>. Accessed Nov. 04,
9 2013.
- 10 19. Fife-Schaw, C. *Statistics FAQ*. University of Surrey, 2013.
11 <http://www.surrey.ac.uk/psychology/current/statistics/index.htm>. Accessed Nov. 12,
12 2013.
- 13 20. BMDP Statistical Software Inc. *BMDP Statistical Software Manual*. BMDP, Los
14 Angeles, USA, 1992.
- 15 21. Field, A. *Discovering statistics: Using SPSS for Windows*. Sage, London, 2000.
- 16 22. Kahn, J. H. Factor analysis in counseling psychology research, training, and practice:
17 Principles, advances, and applications. *The Counseling Psychologist*, Vol. 34, 2006,
18 pp.684-718.
- 19 23. Fabrigar, L.R., Wegener, D. T., MacCallum, R.C., Strahan, E.J., Evaluating the Use of
20 Exploratory Factor Analysis in Psychological Research. *Psychological Methods* Vol.
21 4(3), 1999, pp.272–299.
- 22 24. Patil, V.H., Singh, S.N., Mishra, S., Donavan, D.T. Efficient theory development and
23 factor retention criteria: Abandon the “eigenvalue greater than one” criterion. *Journal of*
24 *Business Research*, Vol. 61, 2008, pp.162-170.
- 25 25. Budaev, S. Using principal components and factor analysis in animal behaviour research:
26 Caveats and guidelines. *Ethology*, Vol. 116, 2010, pp.472-480.
- 27 26. Cortina, J. What is coefficient alpha? An examination of theory and applications. *Journal*
28 *of Applied Psychology*, Vol. 78, 1993, pp.98-104.
- 29 27. SAS. *Usage Note 23136: What does it mean if the intercept is/is not significant? Should I*
30 *remove it from my model?* SAS support. <http://support.sas.com/kb/23/136.html>. Accessed
31 Dec. 12, 2013.
- 32 28. Yates, D., and S. Paquette. Emergency Knowledge Management and Social Media
33 Technologies: A case study of the 2010 Haitian Earthquake. *International Journal of*
34 *Information Management*, Vol. 31, 2011, pp.6-13.
- 35 29. Fayish, A. C., and P. P. Jovanis. Usability of Statewide Web-Based Roadway Weather
36 Information System. In *Transportation Research Record: Journal of the Transportation*
37 *Research Board*, No. 1899, Transportation Research Board of the National Academies,
38 Washington, D.C., 2004, pp.44–54.
- 39 30. Bonsall, P., and M. Joint. Driver compliance with route guidance advice: The evidence
40 and its implications. *Conference: Vehicle Navigation and Information Systems*, Vol. 2,
41 1991, pp.47-59.

- 1 31. Grotenhuis, J., W. Wiegman, and P. Rietveld. The desired quality of integrated
2 multimodal travel information in public transport: customer needs for time and effort
3 savings. *Transport Policy*, Vol. 14, 2007, pp.27–38.
- 4 32. Skoglund, T., and M. Karlsson. Appreciated – but with a fading grace of novelty!
5 Traveller’s assessment of, usage of and behavioural change given access to a co-modal
6 travel planner. *Procedia - Social and Behavioral Sciences*, Vol. 48, 2012, pp.932 – 940.
- 7 33. Hato, E., M. Taniguchi, Y. Sugie, M. Kuwahara, and H. Morita. Incorporating an
8 information acquisition process into a route choice model with multiple information
9 sources. *Transportation Research Part C*, Vol. 7, 1999, pp.109–129.
- 10 34. Khattak, A. J., Y.Yim, and L. S. Prokopy. Willingness to pay for travel information.
11 *Transportation Research Part C*. Vol. 11, 2003, pp.137–159.
- 12 35. Expert Group on ITS for Urban areas. *Guidelines "Multimodal Information"*. European
13 Commission - Directorate-General for Mobility and Transport, 2011.
14 [http://www.predim.org/IMG/pdf/Urban_ITS_Expert_Group_-_DraftGuidelines_-](http://www.predim.org/IMG/pdf/Urban_ITS_Expert_Group_-_DraftGuidelines_-_Multimodal_information_service.pdf)
15 [_Multimodal_information_service.pdf](http://www.predim.org/IMG/pdf/Urban_ITS_Expert_Group_-_DraftGuidelines_-_Multimodal_information_service.pdf). Accessed Feb. 4, 2014.
- 16 36. Kollmuss, A., and J. Agyman. Mind the Gap: Why do people act environmentally and
17 what are the barriers to pro-environmental behavior? *Environmental Education Research*,
18 Vol. 8, 2002, pp.239-260.
- 19 37. Verplanken, B., H. Aarts, and A. van Knippenberg. Habit, information acquisition, and
20 the process of making travel mode choices. *Journal of social psychology*, 1997, pp.539-
21 560.
- 22 38. Behrensa, R., and R. Del Mistroa. Shocking Habits: Methodological Issues in Analyzing
23 Changing Personal Travel Behavior Over Time. *International Journal of Sustainable*
24 *Transportation*, Vol. 4(5), 2010, pp.253-271.
- 25 39. Aarts, H., B. Verplanken and A. Van Knippenberg. Habit and information use in travel
26 mode choices. *Acta Psychologica*, Vol. 96, 1997, pp.1-14.
- 27 40. Kenyon, S. and G. Lyons. The Value of Integrated Multimodal Traveller Information and
28 its Potential Contribution to Modal Change. *Transportation Research Part F*, Vol. 6(1),
29 2003, pp.1-21.