EVALUATING THE EFFECT OF INFORMATION ACCURACY ON TRAVELLERS' CONCORDANCE WITH ADVANCED TRAVELLER INFORMATION SYSTEMS

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ABSTRACT

This paper analyses the behaviour of travellers' in a choice context in which they are assisted by ATIS (Advance Traveller Information Systems). In order to observe travellers' response to information, stated preference approaches are often adopted for data collection. To this aim, at the Department of Transportation Engineering of the University of Naples, a web-based tool (the 'SP Platform'), has been developed and employed for different decision-making analyses.

The aim of this research is to investigate the effects of information accuracy on travelers' concordance. This is done by means of repeated choices from the respondents (panel data), assuming that compliance is somewhat a (part of the) day-to-day process that combines the experiences acquired in the past, the expectation of current conditions and the quality of the available information. One of the key issues in such a kind of experiment is to assess when respondents have learnt how the experiment runs and have established their behaviour, so that the observed choices can be interpreted as instantaneous reactions to experimental stimuli.

In this work such type of experiment is presented, oriented in particular to the identification of the *learned-status* with respect to the experiment. The repeated choices, once the experiment rules and logic have been learnt, are then employed in order to analyze the respondents' compliance with information.

***Keywords**: ATIS; Stated Preference; Traveller's behaviour; Travel simulator; Accuracy, Route-choice, Travel information, Uncertainty.*

1. INTRODUCTION

The *Advanced Traveller Information Systems* have been introduced in order to assist travellers in making travel choices especially when uncertainty is involved. One of the key issues in this field is to study the effect of information in case of different levels of accuracy and different kinds of information, since both affect users' expectations and responses. During the last years several researchers have studied the users' reactions to *Advanced Traveller Information Systems* and some of them (e.g. *Van der Mede et al., 1996; Mahmassani et al, 1998; Chen et al., 1999;Chorus et al., 2009; etc.*), have focused their attention on the travellers' compliance, defined as the attitude in making choices consistent with the received information. To be more precise more of them have focused on modelling travellers' route choice in presence of information, even if only in some cases, researchers have been focused on the effect of information accuracy and of different kinds of information on travellers' compliance with information system (*Mahmassani et al, 1998; Chen et al., 1999*). Furthermore in these studies, they didn't study the effect of information accuracy on respondents' learning, by considering in particular the different kinds of information.

The motivation for which the compliance with information is worth to be studied is strictly related to network effects. In fact, in some cases (*Bifulco et al., 2007*), it has been demonstrated that a high level of compliance is required by ATIS, in order to be effective. However, the relationship between accuracy of information (with reference to different kinds of information) and compliance has been often argued. Information can be defined as accurate when the estimates made by ATIS will be consistent with the travel times travellers will actually have experienced once at destination. This can occur when reliable forecasting methods are adopted (which represents purely the accuracy from the information provider's side) and when the difference between forecasted and experienced travel times is small (accuracy from the drivers' perspective). The latter is determined by a combination of good forecasting methods, the variability of travel times and the experiences realized by the driver. Depending on the day-to-day experiences and the received information, drivers reinforce, or not, the likelihood to trust the information received, thus increasing the likelihood to comply with the information. For an extensive overview of the literature concerning day-to-day decision-making models under uncertainty and information one can refer to *Viti et al. (2005).*
It is very difficult to precisely forecast traffic conditions and ensure consistency between the forecasted traffic conditions and the provided information so compliance is not expected to be always high. This difficulty is exacerbated in case of congested networks by the so called anticipatory-route-guidance problem (*Bottom et al., 2006*). In order to obtain accurate information, the suggestions, based on the estimates on the predicted state of traffic conditions, should consider travellers' reactions to the information itself. These reactions are however dependent on the actual compliance, and thus

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even in forecasting models that account for drivers' reactions 100% accuracy is not expected to be met if compliance behaviour is not fully captured.

The aim of this paper is to study the effect of information accuracy on travellers' compliance using panel data gathered from a series of repeated experiments.
As said, travellers' compliance depends on information accuracy, on travel time variability and on travellers' learning behaviour. These three aspects have been considered explicitly in this study and they have determined the way we designed the experiment, which is described in the following of this paper.

In order to be more precise in our research has been considered the concordance with ATIS and not the compliance. In fact the main difference is that traveller can be defined as compliant-with-ATIS when chooses the suggested route, even if a traveller could be observed to be concordant not only because he/she trusts in the system (is compliant) but also because he/she would have chosen the route in any case. On the base of previous considerations, the set of concordant travellers contains the set of compliant travellers and our analyses are referred to the respondents' concordance with ATIS and not to model the concordance.

A Stated preference experiment has been made by using a travel simulator. In particular the experiment can be considerate as pilot experiment, because of the number of the respondents invited to participate. In particular a web based tool, the 'SP Platform' has been designed at the Naples University (*Bifulco et al., 2009*). It has been employed in order to run several experiments oriented to the analysis of travellers behaviours in ATIS contexts (*Ben-Elia et al., 2010*). The typical experimental procedure is such that respondents are invited to connect to a web page and to simulate their choices by following the suggestions provided by ATIS, after receiving some basic information on the type of trip and on the available travel alternatives. They are requested to make their repeated choices for several successive trials considering the suggestions of the simulated information system. Repeated trials for the same respondent are aimed toward two objectives: 1) to let the respondents be familiar with both the network context and the ATIS performances (learning phase); 2) to observe several reactions of the same respondent with respect to different stimuli.
All the experiments carried out by using the SP Platform have been interpreted (so far) under the basic assumption than a given number of trials is required to reach objective 1 while the following trials allows for the interpretation of the travellers' behaviour on a day-to-day time frame.

This paper is organized as follow: in section *2*, the SP Platform is briefly described, the experiment design and the data collection are shown and discussed; in section *3*, analyses are carried out and results presented; in section *4*, conclusions and remarks are discussed.

2. THE EXPERIMENT

2.1. THE SP PLATFORM

The SP Platform (Figure 1) is a web-based tool aimed at observing travellers' behaviours in simulated ITS (Intelligent Transportation Systems) contexts. Several researchers have designed different travel simulators improving step by step, on the base of previous experiences, several features. For a description of different travel simulators (and related issues) see for instance *Adler et al.(1993), Mahmassani and Jou (1998), Avineri and Prashker (2005; 2006), Bogers (2009), Ben-Elia et al. (2008).* In this research the SP Platform has been used (*Bifulco et al., 2008*). It is implemented in a highly flexible way and is virtually suitable for any kind of SP experiment related to travel choices. The development of this tool has been strongly influenced by an existing one, the TSL (Travel Simulator Laboratory, *Hoogendoorn, 2004*), developed at the University of Delft, to which functionalities the authors have had access during previous researches.

Figure 1: Screenshot of the SP Platform

2.2. DESIGN OF THE SCENARIOS

Here we discuss an experiment aimed at observing route choices in presence of information, implemented on the SP Platform, under different levels of information accuracy and travel time variability.
The information is simulated by means of VMS at a diversion node of the network. The control variables of the experiment are the distribution of actual travel times of the three routes among which the respondents make their choices and the distribution of errors made by ATIS in estimating these actual travel times. The error made by the information system can be computed as the discrepancy between the actual travel times and the estimates made by ATIS.

Respondents are asked to simulate their travel on OD pair connected by three alternative routes among which they can make their choice; moreover they are provided with information by VMS. In particular routes are differently characterized: route 1 is an highway; route 2 a rural road and route 3 an urban road; the length of route 1 is 70 Km, the length of route 2 is 90 Km, finally the length of route 3 is 85 Km. On the base of previous characteristics, the routes can be distinguished in terms of actual travel times and reliability (variance of actual travel times).

Route 1 is the shortest in terms of travel times (42.83 min) but the most unreliable in terms of variance (179.53 min); route 2 is the longest one in terms of travel times (53.03 min) and has an intermediate variance (54.83 min); route 3 is longer than the first one in terms of travel times (52.10 min) but is the most reliable in terms of variance (2.4 min). Note that route 2 is dominated by route 3 in terms of both average travel times and reliability. Because of this, if correctly perceived, it can be assumed as the dominated alternative (see Figure 2).

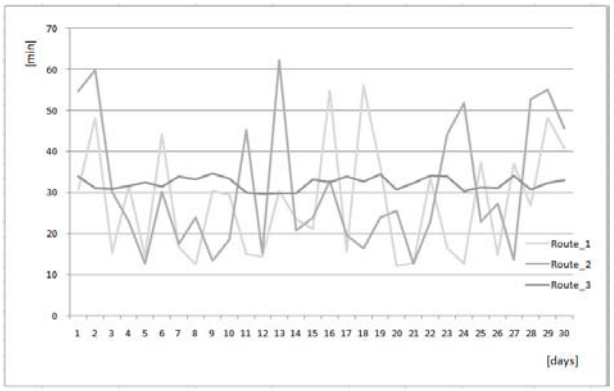

Figure 2: Distribution of actual travel times over "days"

In order to model the relationship between accuracy of information and concordance, three levels of accuracy have been considered. In case of high and intermediate accuracies, the error is obtained from a normal distribution with zero mean and with standard deviation proportional to each routes' coefficient of variation (in case of high accuracy level: *0.25 * CVj;* in case of intermediate accuracy level *0.60 * CVj*). For the low accuracy, a uniform random distribution has been applied whereby the considered boundaries (a, b) are the 85% of the minimum value of actual travel time and 115% of the maximum value of actual travel time.

In case of prescriptive information, ATIS estimates of travel times are employed to compute the ATIS-estimated best route, which is suggested to travellers; thus the ATIS reliability perceived by the travellers depends on if the suggested route actually has been the best one. In our experiment, reliability performances of scenarios 1, 2 and 3 respectively are 18/20, 11/20 and 6/20. In fact the error made by ATIS have be designed in order to obtain that in case of highly accurate scenario, information will be reliable in the most number of time, in second scenario more or less on the half of time, finally in low accurate scenario in a limited number of times.

2.3. SURVEYING

Respondents were requested to make their choices for thirty consecutive times. From trial 1 to 10 the ATIS is not simulated, it is considered to be on-place starting from trial 11. Thus the experiment can be considered as divided in two parts: in the first part respondents' choices were influenced only by experiences; in the second part they were influenced not only by experienced travel times, but also by information with which they are provided by ATIS. Actually, it is expected that during the first part of the experiment the respondents get familiar with the network and with travel times (and their dispersion/reliability over time). Similarly, during the first trials of the second part, the respondents get familiar with the ATIS and its performances (e.g. accuracy).
With reference to literature (*Schofer et al., 1993)* the experiment has been made by considering three kinds of information: prescriptive (respondents are provided with the estimated shortest route), mixed information (combination of descriptive and prescriptive); mixed information with augmented info (the averages of actual travel times of all routes over the last three days are also dispatched). Respondents have been also provided with a feedback on the actual travel times of all routes.
By combining three kinds of information (prescriptive, mixed and mixed with augmented information), with three levels of accuracy, 9 scenarios result. As we have said in the preliminary description of the research, this can be considered as pilot experiment and for this reason only 10 respondents have been randomly assigned; currently the researchers of this study are continuing their experiments, in order to enrich the number for available observations on the base of which they could make their analyses.
The sample was composed as in following described: with reference to the gender the 77.5% are male and the 22.5% female; with reference to the educational attainment the 39% have a bachelor degree or less, the 40% have master degree, and the 21% are PhD; with reference to the age the 30% is born between 1983-1988, the 20% is born between 1975- 1982, the 30% is born between 1940-1974; with reference to the employment the 29% are freelancers or teachers, the 51% are students and 19% are researchers or teachers at university.
For each respondent 30 repeated trials have been observed. The motivation for the respondent was, at each trial, to reach the destination on-time in order to met-up for a job meeting. The more the respondents were able to be on-time, the higher was the score, up to 50 points per trial. Moreover a bonus of 10 points was

assigned at each trial if the respondent was also able to choose the shortest route (see *Bogers and Hoogendoorn 2004*).

3. ANALYSES AND RESULTS

With reference to the experimental context described in section 2, in this paper we analyse: a) the number of trials needed to let the respondents be familiar with the network and the ATIS; b) the effect of the information accuracy on the travellers' concordance and route choices. In other words, we describe in a two-stage analysis the *learning phase* in which drivers aim to get familiar with the travel time distributions, and the relationship between accuracy and concordance when drivers show to have completed the learning phase.

3.1. LEARNING PHASE

As *learning the experiment* we identify the *warming-up phase* process by which, in our context, the respondents of the SP game became aware of the network performances (trial 1 to 10 of the experiment) and of the ATIS performances (from trial 11).

As it is difficult to uniquely identify the number of trials needed for a respondent to get acquainted with the choice alternatives and characteristics, we have chosen to use two different metrics: the *score* (also adopted in *Bogers et al, 2006*), introduced in previous section 2 and the percentage of respondents not choosing the dominated route (route 2). We assume in this case that the respondents will not use the dominated route once they learn that is never the best option over the other alternatives.

For the second part of the experiments (from trial 11th) another indicator is added, which is the percentage of compliant travellers. We expect that this last indicator reaches a stable value when respondents have learned the experiment.

The analyses of the previous indicators are carried out with reference to different accuracy levels.

In order to understand how many trials respondents need to learn about the experiment (in terms of accuracy of information and network performances) a non-parametric test (*Kruskall Wallis test*) has been used. The tests are addressed to evaluate a significant effect of the number of trials on 1) arrival score (see Table 1), 2) on tendency to avoid route 2 (Table 2) and 3) on concordance to the information provided (see Table 3). The first test on arrival score is addressed to show the significant effect of the information. The reference step size is equal to 10 trials.

Results show that arrival scores during the first trials are, in case of high and intermediate levels of accuracy, significantly different than the arrival scores during trials from 11 to 20; moreover no significant difference can be observed, at the same inaccuracy levels, if the arrival scores over trials from 11th to 20th, are compared to those from 20th to 30th. Note that in case of low accuracy level no significant effect of information can be observed because respondents reach too low arrival scores value.

Table 1: Effect of trials on arrival score (Kruskall wallis test)

Trials	High. Lev	Interm. Lev	Low Lev.
Over all	0,000	0,001	0,905
From 1 to 10 vs. from 11 to 20	0,002	0,040	0,527
From 11 to 20 vs. from 20 to 30	0,206	0,096	0,528

In the second and third tests, the reference step size is equal to 5 trials. With reference to the tendency to avoid route 2, as shown in Table 2 in case of *no ATIS experiment*, trials have a non-significant effect (0,005). It can be concluded that the first 5 trials can be considered as learning phase for respondents. Moreover in case of *ATIS experiment*, trials have a significant effect only from 11th to 15th trials (*0.000* at high accuracy; *0.004* for intermediate accuracy; *0.024* for low accuracy).

Table 2: Effect of trials on tendency to avoid route2 (Kruskall Wallis test)

Trials	No ATIS	High. Lev	Interm. Lev	Low Lev.
From 1 to 5 vs. from 6 to 10	0,005			
From 11 to15 vs. from 16 to 20		0,000	0,007	0,024
From 15 to20 vs. from 21 to 25		0,333	0,109	0,066
From 21 to 25 vs. from 25 to 30		1,000	0,327	0,065

The same kind of test has been made on concordance. In particular in this case, the significant effect of trials can be observed only in case of high and intermediate levels, because at lowest level of accuracy of information concordance is lower. On the basis of the obtained results, we can conclude that trials have a significant effect from trial 11th to trial 15th.

Table 3: Effect of trials on concordance (Kruskall Wallis test)

Trials	High. Lev	Interm. Lev	Low Lev.
From 11 to15 vs. from 15 to 20	0,000	0,009	0,330
From 15 to20 vs. from 21 to 25	0,133	0,019	0,183
From 21 to 25 vs. from 25 to 30	0,086	0,956	0,084

3.2. The effect of information accuracy on concordance with ATIS and route choices

The analyses of previous section 3.1 have shown that the respondents can be considered to have learned the experiment starting from trial 15, Then these first 15

trials have been removed from the analyses here made in order to understand the travellers' behaviour.

Table 4 shows that, on the basis of preliminary aggregate percentage, concordance is strictly related to the accuracy of information (see also *Di Pace, 2008*) and in particular that the concordance decreases according with the accuracy. This effect is more evident from the most accurate to the intermediate level than from the intermediate to the lowest accurate. In case of high accuracy, it can be also noted a high attitude toward the best route (also because the suggested route tends to be the shortest one in case of accurate ATIS), as noted also by *Ben-Elia et al. (2010)*. This attitude decreases according with the accuracy as well. In case of the least accurate scenario, a higher attitude toward the most reliable route can be observed, perhaps because respondents perceive choice as more uncertain and are influenced by their risk aversion. Tendency to most reliable routes is consistent with findings in literature like as *Avineri and Prashker (2006), Viti et al.(2005), de Moares et al. (2010).*

Table 4: Aggregate choices at different accuracy levels over all info

Lev. of Accuracy	Share (%)		Compliance
	Shortest Route	Most Reliable	
1	71.76	22.5	85.00
2	61.31	20.66	66.97
3	45.33	27.00	64.17

A more disaggregated analysis allows for identifying some differences in case of different information types. Table 5 shows that in all cases at highest levels of accuracy respondents are highly compliant (they tend to choose route 1, that is most of the times both the shortest and the one suggested by the system). In case of prescriptive information and mixed information the travellers' attitude toward the most reliable route (route 3) increases according to the inaccuracy and also the share of the dominated route increases. This confirms that: 1) travellers get more confused and are less able to identify the shortest and the most reliable routes; b) also because of confusion, travellers still maintain some degree of concordance (optimistic anchoring, *Tversky and Kahnemann, 1974*) and they follow the suggestions even when the dominated route is suggested, and this happens more frequently because the systems is less accurate and supplies more frequently useless information. In case of mixed information with augmentation, all the previous are exacerbated. It can be noted that the concordance increases again to more that 60% and that the share of the dominated route is extremely high (33%). In practice what we are observing is a false concordance. The travellers choose almost randomly and the share of the dominated route is high, as it is relatively high the probability it is suggested by the system. On the other hand, even if the accuracy of the information is the lowest, the augmented information supplies the average (over last days) actual travel time of the routes, and this helps to identify the average shortest route (route 1) with respect to route 3 that, provided its low variance of actual travel times, is likely to be on average the worst route. Since route 1 still is suggested by the system a relatively high number of times (even if only because of random), the false concordance of travellers increases.

Table 5: Aggregate choices at different accuracy levels and at each kind of information

Info	Lev. of Accuracy	Share		
		Compliance	Shortest Route	Most Reliable Route
Prescriptive	1	94.47%	76.07%	22.50%
	2	74.61%	70.00%	14.23%
	3	66.81%	54.54%	21.36%
Mixed	1	82.00%	69.00%	21.50%
	2	77.33%	63.00%	19.00%
	3	62.72%	37.27%	33.45%
Mixed Info +	1	74.50%	68.50%	23.50%
	2	41.50%	47.50%	31.50%
	3	61.00%	43.75%	23.13%

4. CONCLUSIONS AND REMARKS

The paper is addressed to study the travellers' behaviour under ATIS. In particular an experiment has been made by considering different inaccuracy levels and different kinds of information (prescriptive; mixed; mixed with augmented information). Of course results here shown can be referred to preliminary analyses because the considered data have been collected in terms of pilot experiment; in future work, researchers will increase the number of respondents for each scenario in order to consolidate these preliminary results.

Results show a significant effect of information accuracy on the travellers' concordance (e.g. concordance decreases as the inaccuracy increases). In fact, information accuracy seems directly influencing the route choices made by respondents. At higher level of accuracy travellers choose mainly the shortest route (the most suggest route), but when the information accuracy decreases the condition of choices are perceived as more uncertain and for this reason they exhibit the tendency to choose the most reliable route, or even the dominated route alternative, thus "complying" less with the received information.

All these phenomena can be evidenced by proper analyses once the experimental data have been cleaned by the bias induced from the experimental methodology. In fact, it has been proved that the respondents of the SP experiment need some trial in order to understand the networks and be aware of the ATIS performances.

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