On the use of ubiquitous real-time bus passenger information

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Abstract: Ubiquitous real-time passenger information (URTPI) enhances the perceived quality of service of public transport and enables travellers to make better pre-trip and en-route travel choices. The paper presents an exploratory study of the use of URTPI. We analyse the popularity of this kind of information, of the sources through which it is disseminated, and of the contents that it conveys. In particular, we are interested in the effects of trip characteristics and socio-demographic features of passengers. Our findings are based on 1645 responses collected through a bus passenger survey in the city of Edinburgh, UK. We find that access to URTPI is particularly related to the perceived length of the trips and age of the traveller. The most popular source of URTPI is bespoke apps providing information on bus arrival times, although non-residents require more detailed information. The study paves the way for further investigations into the impact of information on passengers' choices.

1. Introduction

Over the last decades, the diffusion of Intelligent Transportation Systems (ITS) has opened the door to solutions contributing to a better travel experience [1]. Nowadays data collected in real-time by ITS can be used for operational and planning purposes as well as to provide information to travellers. For example, automatic vehicle location data can be used to control bus headways but also to provide information on bus arrival times. Real-time information for public transport passengers (hereafter referred to as Real-Time Passenger Information, RTPI) can be disseminated at specific locations (local information), for instance through displays, or be accessible everywhere. The progress of information and communication technologies has made RTPI potentially available everywhere and at any time [2]. We refer to the real-time information available through the Internet as ubiquitous RTPI (URTPI). Existing sources of URTPI are mainly bus/train trackers and journey planners. Bus trackers disseminate information on the arrival time of the next buses at a particular stop, whereas journey planners provide alternative routes for a certain origin-destination. Users can retrieve URTPI directly from the web or using mobile apps. The introduction of passenger information apps, along with the increasing diffusion of internet and smartphones, has changed the face of public transport (PT) passenger information services and, in countries like the UK, URTPI has gained popularity because it allows users to make better travel choices.

Travel information, in general, plays a vital role in travellers' decision making [3]. Location-specific real-time information sources, such as displays at stops, stations or travel shops, offer limited opportunities of planning trips in advance or updating choices en route because passengers can access information only when they have already reached specific locations. On the contrary, URTPI enables travellers to consult the information at any point in space and time, allowing both pre-trip and en route decisions to be made based on an overview of the current status of the services.

The choices enabled by URTPI have the potential to change the demand distribution over the network, improving the performance of the services [4, 5] thus making PT more attractive. The impact of URTPI can be particularly significant in the UK where 72% of people own a smartphone [6]. About 53% of travellers state that they actively look for ways to improve their journeys and more than half of the smartphone users consider them to be essential for their travel experience [7].

Despite the ever-increasing popularity of URTPI among PT passengers and the effort of PT operators and agencies to provide it, surprisingly little is known about the use of URTPI. We contribute to the existing literature with an exploratory study aiming to identify the factors that drive access to URTPI, the choices between different URTPI sources and the relevance of different contents of the information. We focus on urban PT contexts and ordinary service conditions (i.e. no major disruptions). The study is based on a revealed preference (RP) bus survey in Edinburgh.

The paper is structured as follows: the literature review summarises relevant studies concerning RTPI and the factors affecting the use of travel information (both static and real-time). We introduce our methodological approach, both in terms of data collection and data analysis. We present the main findings from the survey regarding access to information and information user preferences. The paper closes with a discussion of the implications of our results and directions for further research.

2. Literature review

Provision of Real-time Travel Information (RTTI) and the benefits gained by the travellers have been explored for several years and a significant number of studies are available in the literature. However, research regarding RTTI has focused mainly on private transport [8–12]. The general conclusion in this context is that the increasing number of methods of access to different information sources is associated with a higher likelihood of changing travel decisions (departure time, route, mode, or even trip cancellation). In particular, internet-based information increases the propensity to change any aspects of trips [13]. Studies have analysed the impact of demographics and trip characteristics on the use of RTTI. Gender, education and income are found to be significant either directly [14] or through the awareness of state-of-the-art travel information [15]. Also, trip length [16–18], trip time [19], and familiarity with the trip [20] influence the use of RTTI.

The body of literature dedicated to the acquisition of information regarding PT is limited compared to that concerning private cars. In the context of public transport systems, passengers have access to "descriptive" real-time information (i.e. an account of the current or predicted conditions of a network and services) regarding vehicle arrival times, service disruptions, and crowding conditions. Real-time information is also elaborated to provide passengers with "prescriptive" indications, i.e. advice or alternatives on the best routes to their destinations according to different criteria [21]. Fonzone [22] found that descriptive RTPI (both local and ubiquitous) is highly sought after by passengers, even when people are familiar with a PT system.

Harmony and Gayah [23] conducted online surveys to investigate the demand for RTPI in the USA. They suggest that demographic and socio-economic status influence passengers' preference regarding PT information. Their results showed that PT captivity leads to higher benefits from RTPI. Maréchal [24] studied URTPI acquisition from multiple sources during travel disruptions for commute trips. The research found that passengers are more likely to use mobile apps, as well as a combination of social and traditional sources, when the source of information (e.g. printed maps or displays) is more important than the content. The latter study also revealed that trip characteristics influence access to information; for longer trips, commuters prefer a combination of mobile apps and Google Maps. Demographics and attitudes were found to have no influence on travel choices.

Farag and Lyons [25] proposed a social-psychological theoretical framework to identify the barriers to the uptake of RTPI. Lack of awareness, inadequate quality and reliability of the information, and habits limit the use of RTPI. In another study [26], the same authors applied attitude theory to investigate the factors associated with train passengers' information use, concluding that preferences about transport modes and personal attitude towards information are strongly related to the use of information. Hardy [27] observed that, one year after launching bus stop displays in London, 50% of people were not aware of the service. Rahman *et al*. [28] studied bus users' awareness of a newly implemented real-time information system and found that male, high-income and infrequent commuters are more likely to be unaware of the available information services.

A recent literature review on RTPI by Brakewood and Watkins [29] discussed existing studies concerning the impacts of RTPI. Waiting time, route choice, ridership and passenger satisfaction are the areas that were explored by the researchers, regarding the impact of RTPI. Empirical studies on the effects of RTPI focus mainly on ridership and waiting time. RTPI is a pre-requisite for a potential growth in ridership in a well-developed transit service [30]. An empirical analysis of the impact of RTPI on ridership in New York City, US, observed an increase in ridership by 2.3% on the largest quartile of routes [31]. Evidence of an increase in ridership is also supported by Tang and Thakuriah [32], who found an increase between 1.8% and 2.2% in route-level ridership in Chicago, US. The larger ridership is due to the increased number of trips made by passengers who already use PT. Also, bus passengers in Seattle were observed to make more trips on a weekly basis after consulting URTPI [33, 34]. The last two studies show higher satisfaction with PT use and an increase in the number of non-commute trips per week made among URTPI users. Zhang *et al.* [35] and Caulfield and O'Mahony [36] also observed improvements in PT passengers' satisfaction as a result of RTPI provision. Watkins *et al.* [37] determined that, when using URTPI, travellers experience shorter actual waiting times. Therefore, the dissemination of URTPI can produce significant reductions in travel time and changes the way travellers use the network.

Findings of the possibility that travel information fosters modal shift are not conclusive. Frei and Gan [38] reported that smartphone-based multi-modal information fosters a shift from car only journeys to the use of park-and-ride solutions. However, the result is not confirmed in a study on the impact of multi-modal real-time information in Lyon, France [39].

The impact of RTPI on route choice has been evaluated mainly by means of modelling. Gentile *et al.* [40] investigated the impact of RTPI available at bus stops on a network with three bus lines, characterised by different headways and travel times for a particular trip. The study discovered that without consulting RTPI at stops, passengers tend to take the slowest but most frequent line (in 87% of cases). However, the choice of the fastest but least frequent one rises by 43% after consulting RTPI. Nökel and Wekeck [41] compared route choice models in frequency-based assignments with passenger information. The authors showed that, based on RTPI, passengers would decide on a route choice set including boarding, alighting and transfers. The study highlighted that, in the presence of RTPI, passenger's expected travel time is dependent on the choice of elements such as bus line and alighting point.

Chen and Nie [42] studied the effect of online information on optimal routing strategy for three different levels of information, i.e. no information, partial information (available for some of the bus lines) and full information (available for all bus lines at a stop). They concluded that information on faster lines are more effective in terms of minimising travel time, thus attracting more users to faster lines with lower frequency. Also, Oliker and Bekhor [43] dealt with the impact of the level of available information on optimal route choice. Their model showed that passengers tend to transfer more when arrival time information for all intermediate bus stops is available than when RTPI displays the boarding stop only. The studies generally conclude that RTPI can change route choice significantly.

Our literature review highlights that RTTI has been studied more in the context of private transport than in PT. Empirical studies on the impacts of RTPI have proven that information can affect ridership and waiting times. Several models have shown that RTPI has the potential to significantly change the distribution of passengers across different services, and above all when the information is ubiquitous. Despite such potential and the interest of PT passengers and agencies in URTPI, knowledge about the users of URTPI and the factors determining the popularity of different contents and sources of information is limited. Such an understanding is needed to improve the information provision strategy.

Some preliminary results from the survey analysed in this paper have been presented in a previous contribution by the same authors [44]. The previous study discusses the use of individual sources of URTPI. The present study takes the analysis forward, revealing the characteristics of URTPI users (independent of the source of the information) and explains the preferences in terms of sources and contents of the information.

3. Case study

Our study is based on a survey involving bus passengers in Edinburgh, UK; a medium-sized (by European standards), wealthy city with a successful public transport system [45]. Edinburgh has a population of over 500,000 inhabitants, 70% of which are in the working age bracket (16-64). It has the lowest unemployment rate in the UK (4.4%) and the annual median income per resident is £29,500.

The public transport system includes about 70 bus lines and one tram line and yields 350k bus journeys per day. The network has a typical hub and spoke structure (Fig. 1), with headways of 5-7 minutes (peak) to 12-20 minutes (off-peak) on the busy lines. Some bus lines have headways of 10-15 minutes in peak hours and up to 30 minutes in off-peak hours. Both kinds of services are available at the surveyed bus stops (see Section 4). Several sources of information are available to bus passengers, both static and real-time. URTPI includes both descriptive and prescriptive information. The sources of information available at the time of the survey are listed in Fig. 5.

Fig. 1. *Bus network of Edinburgh (source: maps-edinburgh.com)*

4. Data collection method

The use of URTPI is studied by means of a Revealed Preference survey, a widely accepted method in travel behaviour studies [46–48]. To minimise the recall bias [49] we preferred a bus stop survey to a postal or an internet-based one, and we asked participants to provide information on the trip they were making at the time of the interview. However, intercept surveys like ours may be affected by length bias due to the time respondents have to stay at the survey location to participate [50]. Our questionnaire required 3-4 minutes, therefore our survey missed passengers turning up at the stops close to the departure time. This is a limitation of our research.

The bus stop survey was supervised allowing participants to ask the surveyors questions if they had any confusion or queries. We used a web-based platform that allowed the survey to be carried out both online and off-line with mobile devices (i.e. phones, Tablets and laptops, etc.). This is a very convenient method for carrying out surveys as it reduces the effort of handling papers, and issues associated with transferring data from a paper-based survey are avoided. The bus stop survey was carried out with Android tablets.

The questionnaire was designed to gather data on the use of URTPI (used sources of information, perceived importance of the information contents provided by URTPI sources) and the travel choices passengers make after consulting it. The design was inspired by the Theory of Planned Behaviour (TPB) [51]. The TPB has been widely applied in the field of transport, mainly to interpret mode choice (for instance, Heath and Gifford [52] and Carrus *et al.* [54] deal specifically with public transport) and driving behaviour [56, 58]. Pronello *et al.* [60] implemented the TPB to design a study of the effects of multimodal real-time information on mode choice. The TPB explains that an individual's choices are shaped by attitudes and norms, which are influenced by the characteristics of the decision maker and the context of choice. Choosing the features of the travellers and trips to be investigated in the survey was based on the findings of the literature review regarding RTPI and the results of a small focus group (made up of university students, familiar with sources of URTPI available in Edinburgh). We collected information regarding perceived trip length and purpose, departure time, familiarity, and about the modes and the PT services available for the trip. Socio-demographic data included age, profession, gender, level of education and residents. The questionnaire comprised 17 questions overall. The 11 questions used in the present study are presented in Appendix A.

The bus stops were selected considering several characteristics. Surveyed stops serve multiple bus lines and are equipped with sources of non-URTPI information (such as maps and displays). The presence of alternative services ensures that passengers are not deterred from accessing information by the limited set of choices that can be taken. Bus stops with high demand were selected to collect a large and mixed sample. The locations of the fifteen bus stops selected for the survey are shown in Fig. 2. The majority of bus lines at these stops travel through the city centre. For each location, bus stops on both sides of the road were surveyed to cover trips to and from the city centre.

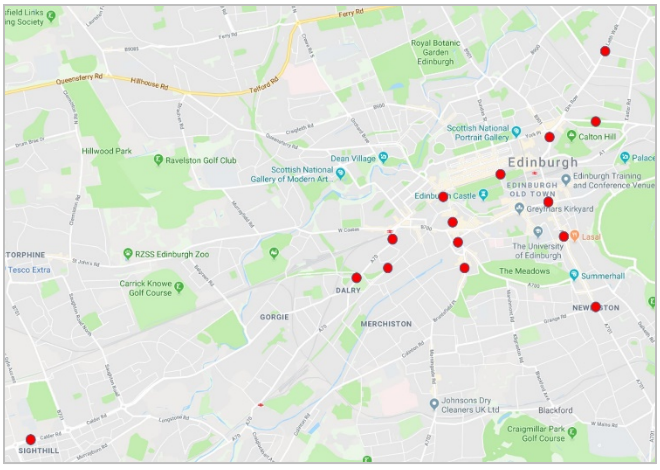

Fig. 2. *Location of the surveyed bus stops*

The final survey took place on nine consecutive days from the 4th to 12th July 2016, including weekends. No special events were going on at that time, but the school summer break had begun. Therefore, our sample might be characterised by a larger than average incidence of tourists.

The data was collected during the morning (07:30-10:30,37% of the respondents) and evening (16:00-18:00, 34.2%) peak hours, and off-peak hours around noon (11:00-13:00, 28.8%). We have not collected data regarding night trips. In general, URTPI can play an important role at night because it helps passengers reduce the wait at bus stops located in unsafe areas. However, Edinburgh is generally perceived as a safe city, therefore we think that this problem is not particularly relevant.

5. Sample characteristics

We collected 1645 responses and the main socio-demographic characteristics are shown in Fig. 3 and Fig. 4. No data is available regarding the PT patronage in Edinburgh. Therefore, to check the representativeness of our sample, we compare its features with the official statistics published by Transport Scotland on behalf of the Scottish government [53] for all Scotland, the UK region of which Edinburgh is the capital (Fig. 3 and Fig. 4).

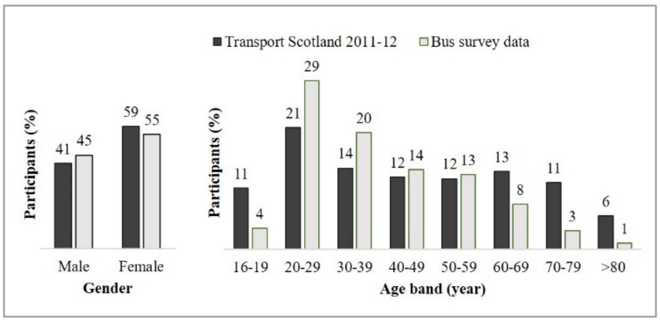

Fig. 3. *Representativeness of bus stop survey data: age and gender*

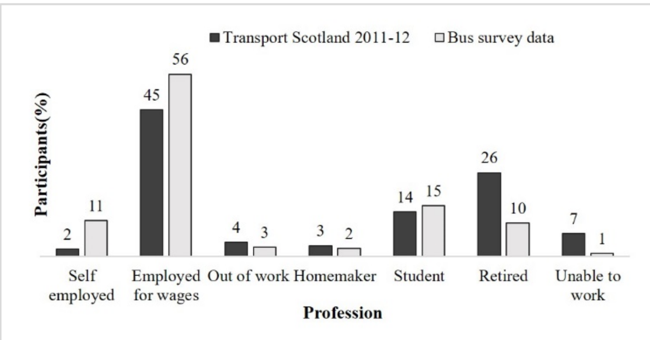

Fig. 4. *Representativeness of bus stop survey data: profession*

There is a statistically significant difference between the age distribution in our sample and the data of Transport Scotland. In our sample, the incidence of young passengers (20 to 40 years old) is higher than in the Scottish data, whereas passengers older than 60 are less represented. Correspondingly, our respondents include more working passengers and less retired and unable to work ones than is found at a Scottish level. These differences are justified by the characteristics of the Edinburgh population which has a higher proportion of young workers than the rest of Scotland [45]. Overall, we believe that the sample is representative, so we do not need to apply weights to the variables regarding demographics for model development.

6. Results

6.1. Access to URTPI

Participants were asked what sources of information they had used for their trip, including URTPI, non-ubiquitous RTPI (i.e. displays at stops) and non-real-time information (i.e. maps and timetables). Fig. 5 shows the use of different sources of information; more than half of the respondents (about 56%) make use of URTPI.

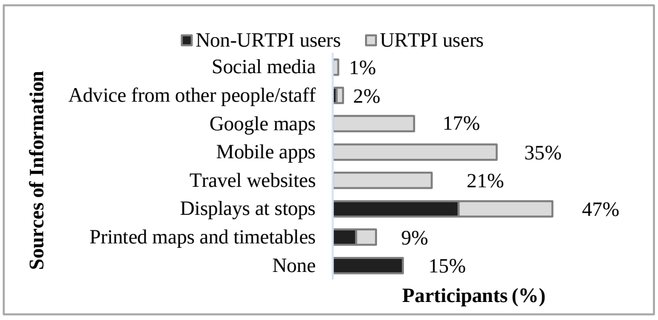

Fig. 5. *Use of different sources of passenger information*

In the survey, the non-users of URTPI were asked why they do not use URTPI. The results in Fig. 6 show that non-users are such mainly because they do not need URTPI; either because they think that the quality of the PT service makes the use of URTPI redundant, or because they are familiar with the trip so they can travel without the support of URTPI. The availability of technology and quality of information play only a minor role in the decision not to use URTPI.

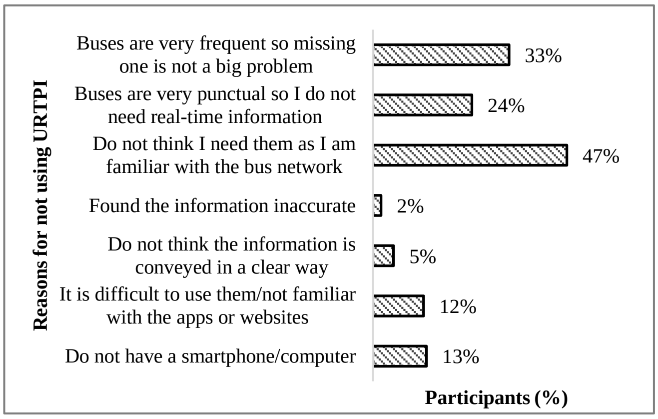

Fig. 6. *Reasons for not using URTPI*

We built a binary logit model [55] to explain access to any form of URTPI in terms of trip characteristics and demographics of respondents (Table 1). We tried different specifications of the model and the final model includes all the predictors that improve the fit even if their effect is not significant.

Table 1 Data structure: Predictors of Use of URTPI

	Variables	Attributes* (% of valid responses)
Trip characteristics	Perceived trip length	*Very short* (5.4%), short (26.7%), medium (52.7%), long (12.8%), very long (2.4%)
	Time of day	*Midday* (28.8%), evening peak (34.2%), morning peak (37%)
	Trip purpose	*Commute* (43.2%), work travel (17.5%), shopping (11.3%), personal/family business (17.5%), leisure (10.5%)
	Familiarity with the trip	*Familiar* (88.3%), unfamiliar (11.7%)
	Alternative mode	*No alternative available* (58.1%), alternative available (41.9%)
	Alternative bus lines	*No alternative available* (33.4%), alternative available (66.6%)
Demographics	Age	18-25 (21.7%), 26-35 (22.6%), 36-45 (52.4%), 46-55 (12.7%), 56-65 (2.4%), *>65* (6.4%)
	Profession	Employed for wages (55.6%), self-employed (10%), out of work (4.4%), homemaker (2.4%), student (15.2%), *retired/unable to work* (10.8%)
	Gender	*Female* (55%), male (45%)
	Education	*Grammar school* (1.4%), high school or equivalent (16.7%), some college credit or no degree (26.7%), university degree (55.7%)
	Residence	*Edinburgh resident* (83.8%), frequent visitor (11.2%), infrequent visitor (2.8%), visiting for first time (2.8%)

* The reference category for that variable in the following model is in italics.

The Omnibus test of model coefficients is significant, confirming that the model explains the data better than a model including only the intercept. The final model predictability rate is 70.4%.

Fig. 7 shows the significant predictors considered in the model and the exponential of the standardised coefficients (β). Bars in grey shows the attributes that are significant at 5% confidence level. Exp (β) value larger than one indicates that respondents are more likely to use URTPI than the reference category (specified in Table 1). Four trip characteristics (Perceived Trip Length, Trip Purpose, Availability of alternative mode and Familiarity of Trip) and three sociodemographic variables (Age, Profession and Residence) significantly affect the use of URTPI. Time of day, availability of alternative bus line, participants' gender and educational level were not found to be statistically significant. URTPI is less common if a trip is perceived as very short. However, the effect of perceived trip length is not linear, with URTPI particularly popular for trips of perceived medium length. URTPI is used to reduce waiting time at stops. For longer trips, the decreasing importance of URTPI may be linked to risk-aversion [57]. Passengers may prefer to arrive at the stop well in advance of their intended service to reduce the risk of missing the bus and consequently URTPI is less frequently used. The availability of alternative modes decreases the probability of using URTPI, showing that URTPI is more appreciated by captive passengers.

As expected, we find that URTPI is less consulted when passengers are on a familiar trip. The popularity of URTPI does not seem particularly related to the purpose of the trip. Surprisingly, URTPI for leisure trips is used significantly more than for commuting trips only, even though the latter can be expected to be time-critical. The use of URTPI clearly declines with age. In principle, this effect might be related to the adoption of simplified decision making approaches by older people, in line with the decrease of human cognitive abilities brought about by ageing [59]. However, in our study, most respondents are younger than 65. Hence, we think that the effect has to be ascribed to the well-known higher affinity toward technology shown by younger generations [61]. Passengers who work or study are more likely to use URTPI compared to those who are retired/unable to work. In our sample, gender is not found to be significant.

6.2. Sources of URTPI

As shown in Fig. 5, about 85% of respondents use at least one source of information, despite the majority of participants (almost 90%) being familiar with their trips. One could expect bus stop displays (available at all the surveyed stops) to be used by a vast majority of passengers, given that they are free and easy to use. However, we find that only 47% of the respondents use them.

This result can be explained by the limited choices passengers can make after they have arrived at the stop, confirming the importance of providing URTPI. Google Maps is an anecdotally popular, Internet-based source of multi-modal RTTI, available to travellers long before bespoke PT mobile apps were introduced. The percentage of respondents relying on Google Maps is half that of passengers using bespoke apps, suggesting that most passengers may not be interested in comparing different modes by using multi-modal information. Static, local sources of information such as printed maps and timetables are still consulted by 9% of the participants, only 2% of passengers who use some sort of travel information do not retrieve any kind of real-time information.

To study the factors affecting the popularity of different types of source of URTPI, we classify the sources in three categories: bespoke mobile apps except Google Maps, travel websites, and Google Maps. Google Maps represents sources of multi-modal information. Websites and apps provide the same kind of PT information, so distinguishing them allows the difference between different dissemination channels to be understood. This gives an indication of the opportunity of investing in apps for PT agencies and operators that already have websites. We consider an additional category for passengers using more than one source of URTPI. The popularity of the different types of

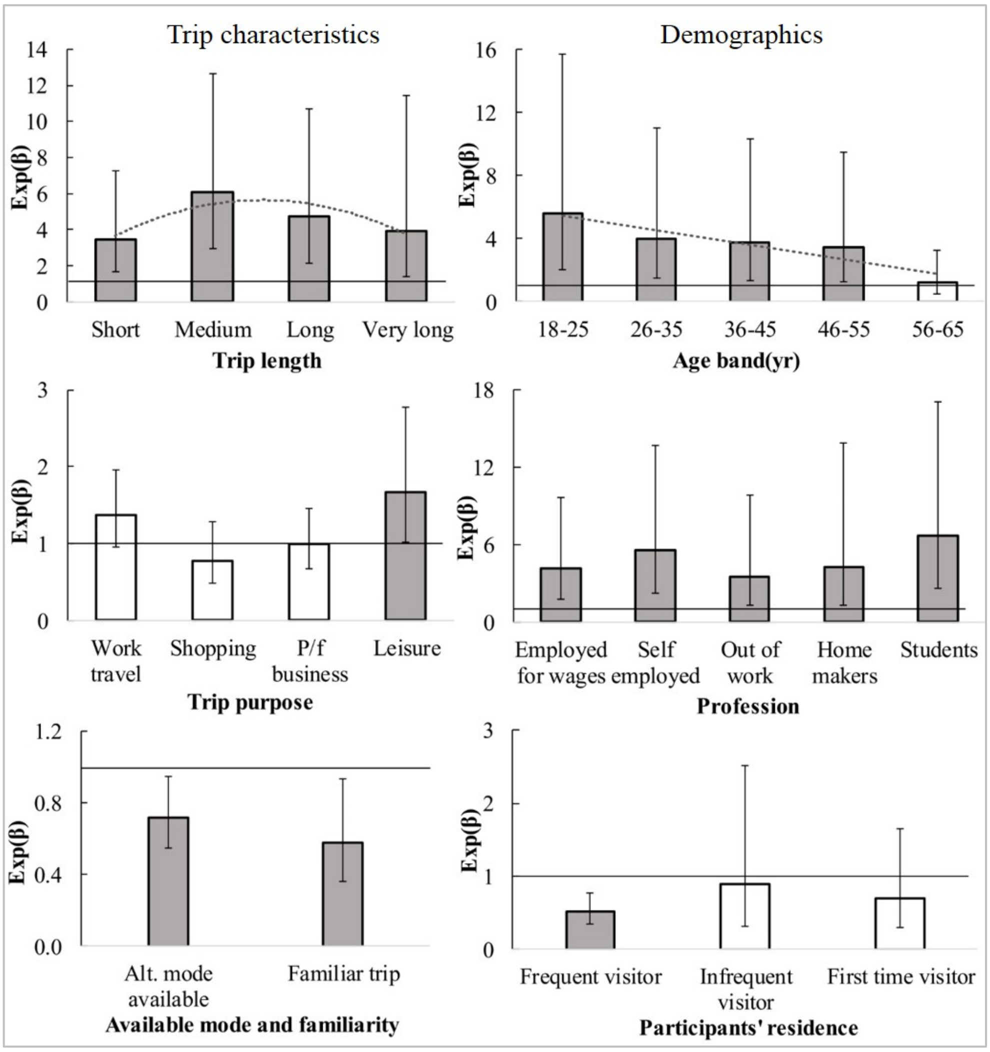

Fig. 7. *Factors affecting the use of URTPI*

URTPI sources is shown in Fig. 8. 41% of URTPI users rely only on mobile apps, whereas 25% use more than one source when making bus trips. We explained the choice among different kinds of sources in terms of trip characteristics and demographics by means of a Multinomial Logit Model [62, 63], a widely used approach when alternatives are independent. The reference category for the dependent variable is mobile apps. For model specification, we adopted the same approach described above for the Logit model. The final model is reported in Table 2. The chi-squared likelihood ratio test is significant, which confirms that the model explains the data better than the baseline model (i.e. intercept only). Compared to familiar and morning trips, passengers use Google Maps and travel websites more for unfamiliar and midday trips. Passengers on an unfamiliar trip cannot rely on prior knowledge of the network geography and this may trigger the use of sources which provide spatial information, not available from bespoke apps in our case. This conclusion is supported by the fact that the less visitors know the city, compared to Edinburgh residents, the more they tend to prefer Google Maps to mobile apps. The lack of significance of the "infrequent visitor" attribute is explained by a limited representation in the sample. The usefulness of geographical information for visitors is confirmed by the fact frequent visitors prefer travel websites and multiple sources to mobile apps only (multiple sources may include mobile apps). Google Maps is less preferred by female passengers compared to male. This can be explained by men having a stronger sense of direction, due to their larger Visuo-Spatial Working Memory as found by some studies [64], and by women preferring exhaustive and elaborative forms of information [65–67].

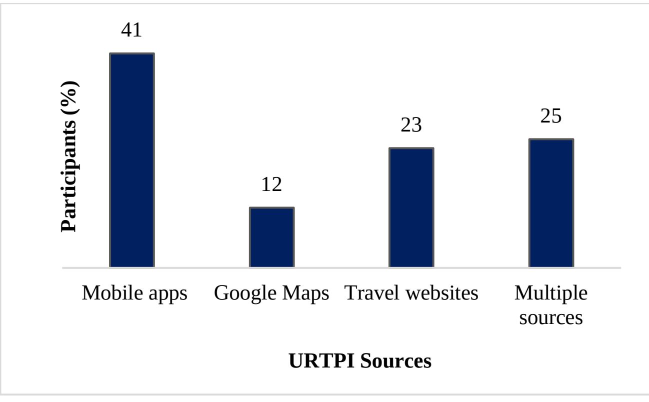

Fig. 8. *Use of different sources of URTPI*

Table 2 Factors affecting preferred sources of URTPI

	Variables (*reference categories*)		Sources of URTPI (*Mobile apps*)		
			Google Maps	**Travel websites**	**Multiple sources**
	Predictors	*Levels*	*Exp(β)*	*Exp(β)*	*Exp(β)*
Trip characteristics	Trip length (*Very short*)	Short	-	-	-
		Medium	-	-	-
		Long	-	-	-
		Very long	-	-	-
	Time of day (*Morning*)	Midday	1.92*	2.02**	-
		Evening	-	-	-
	Purpose of trip (*Commute*)	Leisure	-	-	-
		Work travel	-	1.66*	
		Shopping	-	-	-
		p/f business	-	-	-
	Familiarity of the trip (*Unfamiliar*)	Familiar	0.10***	0.42**	-
	Availability of alternative route (*Not available*)	Available	-	-	-
	Availability of alternative mode (*Not available*)	Available	-	-	-
Demographics	Gender (*Male*)	Female	0.55**	-	-
	Residence (*Edinburgh resident*)	Visiting first time	6.61**	-	-
		Infrequent visitor	-	-	-
		Frequent visitor	3.72**	2.81**	2.19*

* p<0.05 ** p<0.01 *** p<0.001

6.3. Contents of information

URTPI sources provide both real-time (bus arrival time, transfers to other services, journey plans) and static information (route map, stop location). The relevance of different contents of the information is presented in Fig. 9. Our results clearly show that the most important type of information is bus arrival time whereas information on journey plans and transfers is less crucial, probably because of the size and simplicity of the bus network in Edinburgh. Nevertheless, plans and transfers are deemed important by more than half of the respondents. To interpret the importance of the different contents of the information in terms of trip characteristics and demographics, considering the dependent variables are ordinal, we tried to fit ordinal logistic models. However, the test of parallel lines showed that the effects of the predictors on different attributes of the dependent variable were statistically different from each other [68]. Since one of the key assumptions of the ordinal logistic model is violated, we decided to use the SPSS Categorical Regression procedure (CATREG), which we believe is particularly appropriate in an exploratory study like ours because it provides clear indications on the importance of different predictors [69].

We built a model for the content of information. The models were specified by starting from the complete models and eliminating insignificant variables one by one, in order of decreasing importance, until removing further variables reduced the model fit considerably.

Table 3 presents the CATREG standardized model coefficients (β) with significance (p) of the variables and Pratt's relative importance of the variables. Considering the sum of the importance of the variables defining trip features and characteristics of passengers, we can see that the importance of information on bus arrival time and transfers to other services is equally influenced by the type of journey and demographics. Also, the importance of information on bus stop location and journey plan is mainly related to the socio-demographic attributes of the passengers, whilst the relevance of bus route maps depends on the characteristics of the trip.

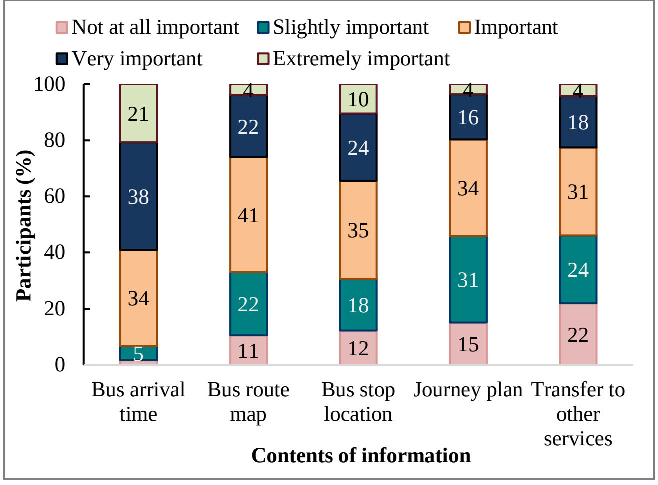

Fig. 9. *Importance of contents of the information*

Perceived trip length is influential on information related to bus arrival times, i.e. Bus arrival time (time of arrival of the first bus) and Transfer to other services (arrival of buses at intermediate stops). In both cases, the importance

Table 3 Factors affecting the importance of contents of the information

	Models	Bus arrival time		Bus route map		Bus stop location		Journey plan		Transfers to other services	
	Predictors	β	Pratt's Imp.	β	Pratt's Imp.	β	Pratt's Imp.	β	Pratt's Imp.	β	Pratt's Imp.
Trip characteristics	Trip length	0.131*	0.157	-		-		-		0.138**	0.137
	Time of day	0.132***	0.175	0.079**	0.017	-		0.096**	0.117	0.101*	0.061
	Trip purpose	0.058**	0.043	0.176***	0.392	0.132***	0.199			0.125***	0.107
	Familiarity of trip			0.080*	0.141	-		-			
	Alternative mode	0.100*	0.097	0.085*	0.055	-		-		0.125***	0.063
	Alternative bus lines	-	0.157	-		-				0.151***	0.196
Demographics	Age	-0.155***	0.321	-		-		-0.131***	0.249	-0.153***	0.191
	Profession	0.139***	0.207	0.080***	0.099	0.172***	0.248	0.137***	0.257	0.132***	0.146
	Gender	-		-		-		0.101*	0.139	-	
	Education	-		-		-		-0.155*	0.240	-0.121*	0.100
	Residence	-		0.148**	0.296	0.264***	0.553	-		-	

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

of the information tends to increase with perceived length. Time of day is significant in all the models except Bus stop location, although its Pratt's relative importance is low in the models of Bus route map and Transfers to other services. Information tends to be more important to passengers when making trips in the morning and less important at midday. Trip purpose is significant for all contents of information except Journey plan. Bus route map tends to be more important for shopping or personal/family business trips and less important for commuting. Bus stop location is more important when making a leisure trip. The two results confirm that geographic information is more important for non-commuting trips, where passengers' choices can be expected to be more flexible. The familiarity of the trip is significant in the Bus route map model, with geographical information being more important for unfamiliar trips. The possibility of choosing between different transport modes to make a trip increases the importance of both temporal (Bus arrival time, Transfer to other services) and geographical (Bus route map) information. However, the relative importance of availability of different modes is small for geographical information, hinting that the modal decision is taken based on time. The presence of alternative bus lines affects the importance of information on transfers; the information is more important in the absence of alternative bus lines, probably because missing transfers generate more disruptions.

Passenger demographics greatly influence the importance of information on Bus stop location and Journey plan. Participants' age and residence are significant in some of the models, with relatively high importance. Similar to access to URTPI, the importance of Bus arrival time, Journey plan and Transfer to other services declines with the increase of participants' age. Profession is significant in all models, although it is difficult to identify a common pattern. Bus arrival time is more important to homemakers which is in line with the results of Kim *et al.* [70] who found that the influence of waiting time at stops on the choice of riding a bus is particularly large for homemakers. Information on transfers and journey plans is more relevant to retired/unable to work respondents. Bus stop location and route maps are important to passengers who are out of work. Female participants give more importance than male participants to information on journey plan, reinforcing the findings regarding Google Maps. The importance of Journey plan and Transfer to other services significantly declines with the increase in education level. This contradicts the findings of Maréchal [48]. The difference may be ascribed to the fact that Marechal's study concerns behaviour under disrupted service conditions, whereas our survey was carried out in ordinary service conditions. Finally, as to be expected, geographical information (Bus route map and Bus stop location) is more important to unfamiliar visitors than to frequent visitors and residents.

7. Conclusion

Although travel information has been widely explored, our literature review identified a lack of knowledge regarding the use of URTPI. In this paper, we present an exploratory study concerning access to URTPI, the preference among URTPI sources and importance of information contents. The study is based on a survey of bus passengers in Edinburgh, UK. Given the location of the survey and the characteristics of our sample, we conclude that our results are valid for medium-sized (in European terms) cities with a large proportion of the population being active and a relatively simple but effective bus network.

We find that URTPI is popular even in a context characterised by frequent bus services and experienced travellers. The access to URTPI is more common for trips perceived as medium length by the travellers and among city residents. In contrast, its use decreases with the age of passengers. In general, mobile apps are more popular than other sources of URTPI but journey planner applications like Google Maps and websites are preferred by people not familiar with the city and/or the trip. The most important content of URTPI is the arrival time of buses, whereas there is less interest in the complete journey plans. In general, the importance of different kinds of information is strongly related to the demographics of the respondents.

The popularity of URTPI supports the importance of efforts made by transport agencies and operators to provide real-time information, accessible everywhere and at every time. We find that residents and visitors have different requirements. Residents ask for apps disseminating information on bus arrival times. More complex information, with detailed instructions covering the whole journey, must be provided to non-residents. Providers should increase the penetration rate of information among older passengers.

URTPI allows passengers to make decisions based on the current status of the network rather than a typical situation. This may lead to a different demand distribution across the available services, with potentially important implications on service quality. This paper does not deal with the important issue of the actual impact of URTPI on passenger choices. Related to this, a longitudinal study would be useful to understand how real-time information and habits interact to determine user behaviour. We have not explored how access to URTPI is influenced by the quality of information and the cognitive costs of using it, which might be related to the decreasing popularity of URTPI with older passengers. Further research is needed to cover more URTPI market segments, in particular, its use for night trips, characterised by reduced frequencies and generally less safe environments. Also, dissemination contexts as the importance of journey plans might increase in more complex, multimodal networks. The bus stop survey may have missed passengers who arrive at the bus stop just in time using URTPI. Therefore, a further study with an on-board survey would be appropriate to capture that user behaviour.

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9. References

1 Figueiredo, L., Jesus, I., Machado, J.A.T., Ferreira, J.R., de Carvalho, J.L.M.: 'Towards the development of intelligent transportation systems', in 'Intelligent transportation systems' (2001), pp. 1206–1211

2 Schweiger, C.: 'Use and Deployment of Mobile Device Technology for Real-Time Transit Information' (2011)

3 Lyons, G.: 'The role of information in decision making with regard to travel.'2006, **153**, pp. 199–212.

4 Cats, O., Koutsopoulos, H.N., Burghout, W., Toledo, T.: 'Effect of Real-Time Transit Information on Dynamic Path Choice of Passengers'*Transp. Res. Rec. J. Transp. Res. Board*, 2011, **2217**, (1), pp. 46–54.

5 Fonzone, A., Schmöcker, J.: 'Effects of Transit Real-Time Information Usage Strategies'*Transp. Res. Rec. J. Transp. Res. Board*, 2014, **2417**, pp. 121–129.

6 Statista: 'Share of mobile phone users that use a smartphone in the United Kingdom from 2010 to 2017'

7 Wockatz, P., Schartau, P.: 'Traveller needs and UK capability study' (2015)

8 Wahle, J., Bazzan, A.L.C., Klügl, F., Schreckenberg, M.: 'The impact of real-time information in a two-route scenario using agent-based simulation'*Transp. Res. Part C Emerg. Technol.*, 2002, **10**, (5–6), pp. 399–417.

9 Buscema, D., Ignaccolo, M., Inturri, G., *et al.*: 'The impact of real time information on transport network routing through Intelligent Agent-Based Simulation', in 'Science and Technology for Humanity (TIC-STH), IEEE Toronto International Conference' (2009), pp. 72–77

10 Zhang, L., Li, J., Zhou, K., *et al.*: 'Design and Implementation of a Traveler Information Tool with Integrated Real-time Transit Information and Multi-modal Trip Planning', in 'TRB 2011 Annual Meeting' (2011)

11 Ganesh, K., Thrivikraman, M., Kuri, J., Dagale, H., Sudhakar, G., Sanyal, S.: 'Implementation of a Real Time Passenger Information System'*Int. J. Eng. Sci. Manag.*, 2012, **II**, (2231), pp. 15–27.

12 Litescu, S., Viswanathan, V., Lees, M., Knoll, A., Aydt, H.: 'Information impact on transportation systems'*J. Comput. Sci.*, 2015, **9**, pp. 88–93.

13 Khattak, A.J., Pan, X., Williams, B., Rouphail, N., Fan, Y.: 'Traveler Information Delivery Mechanisms Impact on Consumer Behavior'*J. Transp. Res. Board*, 2008, **2069**, pp. 7–11.

14 Petrella, M., Lappin, J.: 'Comparative Analysis of Customer Response to Online Traffic Information in Two Cities: Los Angeles, California, and Seattle, Washington'*Transp. Res. Rec. J. Transp. Res. Board*, 2004, **1886**, (02), pp. 10–17.

15 Goulias, K., Kim, T.-G., Pribyl, O.: 'A Longitudinal Analysis of Awareness and Use for Advanced Traveler Information Systems'*J. Intell. Transp. Syst.*, 2004, **8**, (1), pp. 3–17.

16 Lappin, J.: 'Advanced Traveler Information Service (ATIS): What do ATIS Customers Want ?'2000.

17 Targa, F., Khattak, A.J., Yim, Y.: 'Understanding access and use of dynamic travel information', in '82nd meeting of the Transportation Research Board, Washington, DC' (2003)

18 Yim, Y., Khattak, A.J., Raw, J.: 'Traveler Response to New Dynamic Information Sources: Analyzing Corridor and Areawide Behavioral Surveys'*Transp. Res. Rec.*, 2002, **1803**, (1), pp. 66–75.

19 Peirce, S., Lappin, J.E.: 'Why Don't More People Use Advanced Traveler Information?: Evidence from the Seattle Area', in 'Transportation Research Board 83rd Annual Meeting' (2004)

20 van der Horst, R.S.N., Ettema, D.: 'Use of travel information and effects on mode choice for recreational trips', in '84th Meeting of the Transportation Research Board, Washington, DC, USA' (2005)

21 Cats, O., Burghout, W., Toledo, T., Koutsopoulos, H.N.: 'Modeling Real-Time Transit Information and Its Impacts on Travelers' Decisions'*Transp. Res. Board 91st Annu. Meet.*, 2012, pp. 1–8.

22 Fonzone, A.: 'What Do You Do with Your App? A Study of Bus Rider Decision- Making with Real-Time Passenger Information'*Transp. Res. Board*

94th Annu. Meet., 2015, pp. 1–17.
23 Harmony, X.J., Gayah, V. V.: 'Evaluation of Real-Time Transit Information Systems: An information demand and supply approach'*Int. J. Transp. Sci. Technol.*, 2017, **6**, (1), pp. 86–98.
24 Maréchal, S.: 'Modelling the acquisition and use of information sources during travel disruption', in 'UTSG Conference ,Bristol' (2016), pp. 1–12
25 Farag, S., Lyons, G.D.: 'Conceptualising barriers to travel information use', in '39th Annual Universities Transport Study Group Conference, Harrogate, UK' (2007)
26 Farag, S., Lyons, G.D.: 'Explaining public transport information use through attitude theory', in '41st Univer- sities Transport Study Group Conference, London, UK' (2009), pp. 5–7
27 Hardy, N.: 'Provision of Bus Real Time Information To All Bus Stops in London', in '19th ITS World Congress, Vienna, Austria, 22-26 October 2012' (2012), pp. 1–20
28 Rahman, M.M., Kattan, L., Wirasinghe, S.C.: 'Bus Users' Attitudes Toward a Newly Implemented Real- Time Bus Information System', in 'TRB 2017 Annual Meeting' (2017), pp. 1–21
29 Brakewood, C., Watkins, K.: 'A literature review of the passenger benefits of real-time transit information'*Transp. Rev.*, 2018, **0**, (0), pp. 1–30.
30 Brakewood, C., Watkins, K.: 'Quantifying the Impact of Real-Time Information on Transit Ridership', in 'Conference on Advanced Systems in Public Transport' (2015)
31 Brakewood, C., Macfarlane, G.S., Watkins, K.: 'The impact of real-time information on bus ridership in New York City'*Transp. Res. Part C Emerg. Technol.*, 2015, **53**, pp. 59–75.
32 Tang, L., Thakuriah, P.V.: 'Ridership effects of real-time bus information system: A case study in the City of Chicago'*Transp. Res. Part C Emerg. Technol.*, 2012, **22**, pp. 146–161.
33 Ferris, B., Watkins, K.E., Borning, A.: 'OneBusAway: results from providing real-time arrival information for public transit'*Proc. SIGCHI Conf. Hum. Comput. Interact.*, 2010, pp. 1807–1816.
34 Ferris, B.: 'OneBusAway: Improving the Usability of Public Transit'*Comput. Sci. Eng.*, 2011.
35 Zhang, F., Shen, Q., Clifton, K.: 'Examination of Traveler Responses to Real-Time Information About Bus Arrivals Using Panel Data'*Transp. Res. Rec. J. Transp. Res. Board*, 2008, **2082**, pp. 107–115.
36 Caulfield, B., O'Mahony, M.: 'A Stated Preference Analysis of Real-Time Public Transit Stop Information'*J. Public Transp.*, 2009, **12**, (3), pp. 1–20.
37 Watkins, K.E., Ferris, B., Borning, A., Rutherford, G.S., Layton, D.: 'Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders'*Transp. Res. Part A Policy Pract.*, 2011, **45**, (8), pp. 839–848.
38 Frei, A., Gan, H.: 'Mode Switching Behavior with the Provision of Real-Time Multi-Modal Traveler Information'*Transp. Res. Board 94th Annu. Meet.*, 2015, pp. 1–18.
39 Pronello, C., Simãob, J.R.V., Rappazzo, V.: 'Can the multimodal real time information systems induce a more sustainable mobility ?', in 'TRB 2016 Annual Meeting' (2016), pp. 1–16
40 Gentile, G., Nguyen, S., Pallottino, S.: 'Route Choice on Transit Networks with Online Information at Stops'*Transp. Sci.*, 2005, **39**, (3), pp. 289–297.
41 Nökel, K., Wekeck, S.: 'BOARDING AND ALIGHTING IN FREQUENCY-BASED TRANSIT ASSIGNMENT', in 'TRB 2009 Annual Meeting' (2009), pp. 1–17
42 Chen, P.W., Nie, Y.M.: 'Optimal transit routing with partial online information'*Transp. Res. Part B*, 2015, **72**, pp. 40–58.
43 Oliker, N., Bekhor, S.: 'A frequency based transit assignment model that considers online information'*Transp. Res. Part C*, 2018, **88**, (January), pp. 17–30.
44 Islam, M.F., Fonzone, A., MacIver, A., Dickinson, K.: 'Modelling factors affecting the use of ubiquitous real-time bus passenger information', in '5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)' (2017)
45 The City of Edinburgh Council: 'Edinburgh by Numbers 2017' (2017)
46 Kristof, T., Lowry, M., Rutherford, G.S., Kristof, T., Lowry, M., Rutherford, G.S.: 'Assessing the Benefits of Traveler And Transportation Information Systems' (2005)
47 Chorus, C.G., Molin, E.J.E., Arentze, T.A., Hoogendoorn, S.P., Timmermans, H.J.P., Van Wee, B.: 'Validation of a multimodal travel simulator with travel information provision'*Transp. Res. Part C Emerg. Technol.*, 2007, **15**, (3), pp. 191–207.
48 Maréchal, S.: 'Modelling the acquisition of travel information and its influence on travel behaviour'. Imperial College London, 2016
49 Bowling, A.: 'Mode of questionnaire administration can have serious effects on data quality'*J. Public Health (Bangkok).*, 2005, **27**, (3), pp. 281–291.
50 Nowell, C., Stanley, L.R.: 'Length-Biased Sampling in Mall Intercept Surveys'*J. Mark. Res.*, 1991, **28**, (4), pp. 475–479.
51 Ajzen, I.: 'From Intentions to Actions: A Theory of Planned Behavior', in 'Action Control' (1985), pp. 11–39
52 Heath, Y., Gifford, R.: 'Extending the theory of planned behavior: Predicting the use of public transportation.'*J. Appl. Soc. Psychol.*, 2002, **32**, pp. 2154–2185.
53 Transport Scotland: 'Bus and Coach Statistics 2011-12' (2013)
54 Carrus, G., Passafaro, P., Bonnes, M.: 'Emotions , habits and rational choices in ecological behaviours : The case of recycling and use of public transportation'*J. Environ. Psychol.*, 2008, **28**, pp. 51–62.
55 Ben-Akiva, M., Lerman, S.R.: 'Discrete Choice Analysis: Theory and Application to Travel Demand' (1985)

56 Paris, H., Broucke, S. Van Den: ‘Measuring cognitive determinants of speeding : An application of the theory of planned behaviour’*Transp. Res. Part F*, 2008, **11**, (3), pp. 168–180.
57 Palma, A. De, Lindsey, R., Picard, N.: ‘Risk aversion, the value of information and traffic equilibrium’2008, (33).
58 Forward, S.E.: ‘The theory of planned behaviour : The role of descriptive norms and past behavior in the prediction of drivers ’ intentions to violate’*Transp. Res. Part F Psychol. Behav.*, 2009, **12**, (3), pp. 198–207.
59 Sharit, J., Czaja, S.J., Pirolli, P.: ‘Investigating the Roles of Knowledge and Cognitive Abilities in Older Adult Information Seeking on the Web’2008, **15**, (1).
60 Pronello, C., Simão, R. veiga P.J., Rappazzo, V.: ‘The effects of the multimodal real time information systems on the travel behaviour’*Transp. Res. Procedia*, 2017, **25**, pp. 2681–2693.
61 Seebauer, S., Stolz, R., Berger, M.: ‘Technophilia as a driver for using advanced traveler information systems’*Transp. Res. Part C Emerg. Technol.*, 2015, **60**, pp. 498–510.
62 Hensher, D.A., Rose, J.M., Greene, W.H.: ‘Applied choice analysis’ (2015)
63 Washington, S.P., Karlaftis, M.G., Mannering, F.: ‘Statistical and econometric methods for transportation data analysis’ (Chapman and Hall/CRC, 2010)
64 Coluccia, E., Louse, G.: ‘Gender differences in spatial orientation : A review’*J. Environ. Psychol.*, 2004, **24**, pp. 329–340.
65 Meyers-Levy, J.: ‘The Influence of Sex Roles on Judgment’*J. Consum. Res.*, 1988, **14**, (4), pp. 522–530.
66 Kim, D., Lehto, X.Y., Morrison, A.M.: ‘Gender differences in online travel information search : Implications for marketing communications on the internet’2007, **28**, pp. 423–433.
67 Okazaki, S., Hirose, M.: ‘Does gender affect media choice in travel information search? On the use of mobile Internet’*Tour. Manag.*, 2009, **30**, (6), pp. 794–804.
68 UCLA: Statistical Consulting Group: ‘ORDERED LOGISTIC REGRESSION | SPSS ANNOTATED OUTPUT’, https://stats.idre.ucla.edu/spss/output/ordered-logistic-regression/
69 IBM Knowledge Center: ‘Categorical Regression (CATREG)’, https://www.ibm.com/support/knowledgecenter/en/SSLVMB_22.0.0/com.ibm.spss.statistics.help/spss/categories/idh_catr.htm
70 Kim, J.-K., Lee, B., Oh, S.: ‘Passenger Choice Models for Analysis of Impacts of Real-Time Bus Information on Crowdedness’*Transp. Res. Rec. J. Transp. Res. Board*, 2009, **2112**, pp. 119–126.

10. Appendix A: Survey Questionnaire

Table 4: Survey questionnaire

Q. Which sources of information are you using for this journey? Please select all that apply.	• None • Printed maps and timetable • Displays at stops • Lothian Buses or other websites on phone • Lothian Buses or other websites on Computer • Mobile apps • Google maps • Other people advice/staff advice • Facebook • Twitter
For users of URTPI sources- Q. When have you used these sources of information for this journey?	• Once before starting journey • More than once before starting journey • Once during the journey (En route) • More than once during the journey (En route)

Q. Please rate the importance of the information to you. Please select from the drop-down list.		N/A	Not at all important	Slightly important/ Neutral	Impor-tant	Very Important	Extre-mely Important
	Bus arrival time	❑	❑	❑	❑	❑	❑
	Bus route map	❑	❑	❑	❑	❑	❑
	Bus stop location	❑	❑	❑	❑	❑	❑
	Journey plan from start to final destination	❑	❑	❑	❑	❑	❑
	Transfers to other bus routes	❑	❑	❑	❑	❑	❑

Q. How would you categorize your journey?	Trip Length	❑Very short ❑Short ❑Medium ❑Long ❑Very long
	Familiarity of the trip-	❑Familiar with this route ❑Unfamiliar with this route
Q. For this journey, could you have used-	Different bus routes	❑Yes ❑No
	Different alternative modes (walking, cycling, etc.)	❑Yes ❑No

Q. What is the purpose of this journey?	• Travelling to or from home, work • Work travel • Shopping • Personal/Family business • Leisure
Q. How would you classify yourself?	• Edinburgh resident • Frequent visitor in Edinburgh • Infrequent visitor in Edinburgh • Visiting Edinburgh for first time
Q. What is your educational level?	• Grammar school • High School or equivalent • Some college credit, no degree • University degree • Other
Q. What is your profession?	• Employed for wages • Self-employed • Out of work and looking for work • Out of work but not currently looking for work • Homemaker • Student • Retired • Unable to work
Q. Your gender?	• Female • Male
Q. Your age?	