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Knowledge of the Concept Light Rail Transit: Exploring its relevance and identification of the determinants of various knowledge levels

Lieve Creemers[1*], Hans Tormans[1], Tom Bellemans[1],
Davy Janssens[1], Geert Wets[1], Mario Cools[2,3,4]

[1]Transportation Research Institute (IMOB),
Hasselt University,
Wetenschapspark 5 bus 6,
BE-3590 Diepenbeek, Belgium
Phone: +32(0)11 26 91{34, 27, 28, 58}
E-mail: {lieve.creemers, hans.tormans, tom.bellemans, davy.janssens, geert.wets}@uhasselt.be

[2]Université de Liège,
Local Environment Management and Analysis (LEMA),
Chemin de Chevreuils, 1 Bât. B52/3,
BE- 4000, Liège, Belgium
Phone: +32(0)4 366 48 13
E-mail : mario.cools@ulg.ac.be

[3]KU Leuven, Campus Brussels (HUBrussel),
Center for Information Management, Modeling and Simulation,
Warmoesberg 26,
BE-1000 Brussels, Belgium

[4]Business Informatics Research Group,
Hasselt University,
Agoralaan Gebouw D,
BE-3590 Diepenbeek, Belgium

* Corresponding author

Abstract

This paper explores the knowledge of the concept 'Light Rail Transit' (LRT) in the context of implementing a Light Rail system in a (sub)-urban region. To this end, three models are estimated: a first model to explore the role of knowledge on modal choice, a second one to identify the determinants of the level of knowledge and a third model to identify the determinants of a cognitive mismatch between actual (real) knowledge and perceived knowledge. The first model (a negative binomial regression model) underlines the significant relation between knowledge of the concept LRT and modal choice. Given the lack of knowledge of the concept 'Light Rail Transit' revealed by the descriptive results, it is of crucial importance to raise the level of knowledge. Knowledge acquisition can be based on transit experiences and information provision. To explore how information campaigns should be constructed and which target groups should be approached, the factors influencing travelers' knowledge and the determinants of a cognitive mismatch are identified by a Multinomial Logit Model (MNL-model) and a Binary Logit Model. The results show that various socio-economic variables as well as socio-psychological variables are significantly influencing actual knowledge and significantly influencing a cognitive mismatch. Among these variables, employment, gender, perception of ticket price of Public Transit (PT) and expectations with regard to seat availability in the LRT-vehicle are the most influential ones.

Keywords

Light Rail Transit, Determinants, Cognitive mismatch, Stated Knowledge, Perceived Knowledge, Actual Knowledge

1. Introduction

The previous decades were characterized by a considerable increase in car traffic (Blythe, 2005; Gifford & Steg, 2007). Induced by population growth, suburbanization and increase in economic welfare which resulted in higher car ownership levels, car use in the European Union steadily grew by 22% between 1995 and 2010 and was even responsible for 84% of all inland passenger transport in 2010, followed by bus (9%) and rail (7%) (European Environment Agency, 2012). Due to the increasing car use, societies are confronted with a variety of externalities, including reduced accessibility and mobility due to congestion, higher levels of air pollution and energy consumption, and decreased urban quality (Bhattacharjee and Goetz, 2012; Dell'Ollio et al., 2012; Gifford and Steg, 2007).

To combat the above-mentioned externalities within the broad perspective of achieving a more sustainable transport system, car use restrictive policy measures are on the political agenda in many countries. Travel Demand Management (TDM) measures, which in general focus on the more efficient use of transportation resources, are highly related to this kind of measures. A comprehensive list of demand management strategies is provided by the Victoria Transport Policy Institute (VTPI, 2013), like for instance improvements in transit supply (e.g. Forsey et al., 2013), congestion pricing (e.g. Cools et al., 2011) and Park&Ride systems (e.g. Holgùin-Veras et al., 2012).

In the context of improving Public Transit (PT) supply, implementing a Light Rail Transit (LRT) system in a (sub)-urban region might contribute to mitigate congestion on regional level. E.g. in Flanders, the Dutch speaking region in the northern part of Belgium, the (monopolistic) Flemish public transport company "De Lijn", is planning large infrastructure investments (De Lijn, 2002; Varinia, 2008), with a clear emphasis on the construction of different Light Rail systems. However, investments in public transit are often not sufficient in reducing car use (Stopher, 2004), and should be complemented by psychological and behavioral strategies, consisting of information and persuasion techniques, which intend a voluntarily shift towards more sustainable travel mode choice (Bamberg et al., 2011). This is confirmed by various studies which state that a lack of system knowledge can be considered as an important barrier of public transport use (Bonsall et al., 2004; Brög, 2002; Dziekan and Dicke-Ogenia, 2010; Pedersen et al., 2011). In particular, Jones and Sloman (2003) state that travelers often lack information on travel alternatives and that travelers should be better informed about it, for instance by convincible marketing campaigns. In addition, Dziekan (2008) states travelers can only choose between travel options of which they are sufficiently aware. Especially habitual travelers are not aware of the complete set of travel options, even when the alternative options have more benefits in terms of travel time, travel costs and environmental costs. As a result, the traveler is not always taking the optimal choice (Dziekan and Dicke-Ogenia, 2010).

To investigate the importance of a deeper understanding of the factors influencing travelers' knowledge of LRT, two main research questions are investigated in this paper. First, it is explored whether general knowledge of LRT has an influence on modal choice. Second, the different influencing factors of the level of knowledge are identified. From behavioral theory point of view, these research questions relate especially to the third stage of the Seven Stages of Change model, as described by Jones and Sloman (2003). The latter model reflects the cognitive and motivational difficulties which individuals encounter when changing their behavior. According to the model, behavioral change involves seven stages: (*i*) awareness of key issue, (*ii*) acknowledging relevance, (*iii*) perception of options, (*iv*) evaluation of options, (*v*) making a choice, (*vi*) experimental behavior and (*vii*) habitual behavior. This study explores whether the traveler is sufficient aware of the concept of Light Rail Transit (stage 3) and whether the new option is considered as a viable transport option (stage 4).

The remainder of the paper is structured as follows. First, a literature review is given in Section 2. Consequently, Section 3 describes the data that was collected as part of this study. Section 4 explains the theoretical background of the applied statistical methodology. Thereupon, the results of the descriptive statistics of the level of knowledge of the concept LRT and the results of the statistical analysis are discussed in Section 5. Finally, Section 6 provides the most important conclusions and formulates policy recommendations and avenues for further research.

2. Literature Review

2.1. Modal Choice

2.1.1 Determinants

A recent literature review with respect to modal choice decisions was conducted by De Witte et al. (2013). They identify a wide range of determinants influencing the complex decision process, which they categorize into 4 groups: (*i*) individual socio-demographic factors, (*ii*) spatial characteristics, (*iii*) journey characteristic indicators, and (*iv*) socio-psychological factors. The first three categories concerns objective determinants, while the latter category relates to subjective/cognitive factors.

Typical individual and socio-demographic factors influencing mode choice are age, gender, household size, employment status, income and car ownership (Chatterjee, 2011; Elias and Shiftan, 2012; Habib et al., 2009; Kim and Ulfarsson, 2008; Popuri et al., 2011; Stradling, 2011). Focusing explicitly on LRT, Creemers et al. (2012) identified age, sex and number of cars in the household as relevant factors. In addition, Mackett and Babalik-Sutcliffe (2003) found that high car ownership and high incomes reduce Light Rail ridership.

With regard to journey characteristics, various (mode-specific) travel time components contribute in explaining mode choice, including waiting time, park search time, congestion delay time, transfer time, in vehicle travel time and access and egress time (Arentze, 2013; Arentze and Molin, 2013; Creemers et al., 2012; Dell'Ollio et al., 2012; Diana, 2010). In addition, various cost components contribute to the mode preference as well: ticket costs, fuel costs, parking costs and costs for Park & Ride were all found to significantly influence modal choice (Arentze, 2013; Arentze and Molin, 2013; Creemers et al., 2012). Furthermore, various service-quality attributes contribute significantly to the mode choice decision process, including seat availability, the necessity of making transfers and punctuality of transit systems (Arentze and Molin, 2013; Creemers et al., 2012; Outwater et al., 2011). In addition, the importance of trip motive on modal choice was demonstrated by Stradling (2011) and Creemers et al. (2014). Finally, Creemers et al. (2014) underlined the significant effect of weather conditions on modal choice.

Concerning spatial indicators, it is shown that transport availability (e.g. indicated by frequency of public transport) influences modal choice (Stradling, 2011). Transport availability is often related to population density, which is positively associated with rail transit ridership (Loo et al., 2010). In addition, land use features were found to influence modal choice (Currie et al., 2011; Loo et al., 2010; Stradling, 2011). In particular, mixed land-use in terms of residence, shops, workplaces etc. relate to more sustainable travel mode choice decisions (Cervero, 2002; Loo et al., 2010).

Socio-psychological factors refer to the cognitive process involved in the modal choice of a traveler. Among these factors are the formation of habits (e.g. Diana, 2010; Eriksson et al., 2008; Loukopoulos and Gärling, 2005), the lack of awareness of particular modes (e.g. Rose and Marfurt, 2007), problem awareness regarding environmental problems (e.g. Jones and Sloman, 2003), personal enjoyment such as convenience, discomfort and intrusive arousal (e.g. Handy et al., 2010), attitudes and perceptions (e.g. Diana, 2010; Elias and Shiftan, 2012; Gatersleben and Appleton, 2007; Shiftan, 2008; Stradling, 2011) and familiarity and experience of the transport mode (Mattson et al., 2010; Stradling, 2011). Scherer (2010) and Scherer and Dziekan (2012) explored the reasons why travelers have a higher preference for rail transport in comparison to bus-system given a similar level of service. They stated that this rail factor is mainly driven by emotional and social attributions such as attractiveness, enjoyment, convenience, experience/knowledge, and habit. Other factors related to the perception of qualitative attributes of the transit system and transit vehicle are perceived reliability, ride comfort, availability of seats, heating, air-conditioning, sufficient legroom, etc..

Despite their relevance (e.g. Creemers et al., 2012; Diana, 2010; Elias and Shiftan, 2012; Heinen et al., 2011), subjective factors are more difficult to quantify and are therefore less often included in mode choice analysis. The role of subjective factors on mode choice decisions is even more important in the context of the introduction of a new transport mode on the transport market. Neglecting subjective factors leads to biased demand estimations for the new transport services (Diana, 2010). Furthermore, the importance of subjective factors is acknowledged by numerous studies that recommend the inclusion of subjective factors in mode choice models by means of latent variables (Arentze and Molin, 2013; Diana, 2010; Galdames, 2011; Scherer, 2010).

2.1.2 Knowledge and Misperceptions

Of particular interest in this paper, is the role of misperceptions and lack of knowledge as socio-psychological factor influencing mode choice. Several studies state that sub-optimal travel decisions might arise when they are based on a distorted view of the actual situation (Bonsall et al., 2004; Chorus et al., 2007; Gardner and Abraham, 2007; Guo, 2011; Pedersen et al. 2011). In particular, Gardner and Abraham (2007) investigated the determinants of car use and their results revealed misperceptions with regard to journey times of car and public transit. In general, public transit was problematized while car driving was idealized. This is consistent with research performed by Bonsall et al. (2004), which indicated that people with little experience of bus use generally overestimate bus journey attributes (e.g. fares, access/egress, waiting and in-vehicle travel time) and generally underestimate car journey attributes. In addition, Pedersen et al. (2011) found that some car users are willing to change towards public transit if the level of service (LOS) is improved. However, they indicated that car users underestimate the LOS-quality of public transit and are consequently subject to biased perceptions. They mention a lack of knowledge and experience of the transit system as a possible explanation for these misperceptions. Notwithstanding, these kind of distortions have far-reaching consequences which in general encourage car use and adversely affect more sustainable modes of transport.

Dziekan (2008) explored how Public Transit knowledge is structured in human mind and found a hierarchical structure consisting of three levels. At the first level, general knowledge of public transport is acquired. In this phase, the traveler should be made aware of a public transport option for a particular trip. The second level relates to the identification of the PT-transport sub-mode, e.g. bus, train or LRT. In general, it was found that rail-bound transport is better represented in memory than buses. The third and highest level of the hierarchy is the identification of the PT-line in terms of name and service levels. The research presented in this paper, can be framed in the first and the second level of this hierarchical structure. The traveler should be made sufficiently aware of a feasible PT-option for regional trips and that this trip can be made by the new LRT-network.

Besides, knowledge with respect to PT systems can be linked to the Seven Stages of Change model, as was outlined in the introduction. The latter model assumes that change is a process in time instead of an event and combines features from the theory of planned behavior and the transactional model of change (Gatersleben and Appleton, 2007; Jones and Sloman; 2003). The model reflects the cognitive and motivational difficulties which individuals encounter when changing their behavior. Recall that in the Seven Stages of Changes model, behavioral change involves seven stages: (*i*) awareness of key issue, (*ii*) acknowledging relevance, (*iii*) perception of options, (*iv*) evaluation of options, (*v*) making a choice, (*vi*) experimental behavior and (*vii*) habitual behavior. Contextualized for this study, the stages can be described as follows. Stage 1: the traveler is aware of the externalities associated with high car use levels (stage 1). Stage 2: the traveler is looking for ways to change his/her behavior (stage 2). Stage 3: the traveler is sufficient aware of the concept of Light Rail Transit and perceives the typical main characteristics correctly. Stage 4: the traveler has sufficient knowledge of the new transport mode to consider it as a viable option to travel. Stage 5: the traveler decides on the intention to use LRT as a transport mode for certain trips. Stage 6: the traveler tries out the new mode for a short time. Stage 7: If the experience with the new mode is positive it may become a permanent or even habitual behavior.

2.2. Information and Marketing

2.2.1 Increasing Knowledge and Addressing Misperceptions

Providing information to the travelers plays a crucial role in knowledge acquisition (Chorus et al., 2007; Rose and Ampt, 2001) and therefore contributes to dismissing distortions in human perceptions. This is confirmed by Dziekan (2008), who stated that knowledge of the public transport system will increase through professional marketing and information campaigns. Moreover, Cronin and Hightower (2004) argued that informing travelers about the public transit service is one of the most important objectives of marketing campaigns. In this regard, Diana (2010) highlights that marketing mobility services that are unknown by the users by solely relying on their competitiveness in terms of performances could be insufficient. Information campaigns should be targeted at lowering the cognitive burden undertaken by potential customers, willing to figure out how the innovating service works (Diana, 2010).

Dziekan (2007) investigated the learning process associated with the use of an unfamiliar public transport system in Stockholm and concluded that a certain cognitive effort is required to learn the system. Dziekan (2007) illustrated that knowledge was acquired very quickly in the first days of using the public transport system and concluded that it is vital to provide information to the traveler in the very beginning to support this learning process. Brög (2002) and Dziekan (2008) state that using the system and gaining experience will correct distorted perceptions in people's thinking and will raise the level of knowledge. Also Pedersen et al. (2011) and Gardner and Abraham (2007) claimed the importance of experiencing public transit in correcting biased perceptions of travelers. After all, Pedersen et al. (2011) showed larger PT-satisfaction of car users after a trial-transit project in order to correct their misperceptions. In this context, Mackett and Babalik-Sutcliffe (19) showed that offering (temporally) free travel enlarges the travelers' knowledge of the Light Rail system, which in turn augments ridership levels.

Beale et al. (2007) explored whether public transit's information enriching campaigns could correct misperceptions (e.g. overestimating in-vehicle travel time, waiting time, fares…) that are negatively affecting bus use. A first trial, a general campaign, focused on mitigating common misperceptions by incorporating "facts" in the marketing material. The results of the marketing campaign were mixed. Some groups increased their bus use while others, particularly young males and travelers with little experience of buses, embedded their negative opinions even more. To prevent such unwanted effects of a general campaign, Beale et al. (2007) adopted a more targeted approach. The second trial was tailored at mitigating misperceptions of travelers who did not use public transit often but were willing to consider doing so. The results of the tailored approached indicated an increase in bus use, especially by males, pointing out that some misperceptions were discarded.

2.2.2 Marketing segmentation

Travelers are very diverse and respond in a different way to marketing campaigns (Beale et al., 2007). As a result, marketing and information campaigns that are fine-tuned on specific target groups lead to more efficient and effective results, as they will better match backgrounds of the traveler. Segmentation approaches in the field of transportation are often based on general socio-economic characteristics (age, gender, income, occupation, household size and automobile ownership), trip characteristics (trip purpose, time, trip destinations…), mode choice (car, transit) and travelers attitudes (e.g. with regard to status, privacy, comfort, excitement towards various modes, environmental awareness) (Cronin and Hightower, 2004; Diana and Mokhtarian, 2009b; Haustein and Hunecke, 2013; Hunecke et al., 2010; Shiftan et al., 2008). Recently, attitude-based market segmentation is gaining more attention, especially in the context of sustainable transportation (Anable, 2005; Hunecke et al., 2010; Li et al., 2013; Pronello and Camusso, 2011; Yang et al.). Attitude-based segmentation shows greater variation in mobility behavior and provides a deeper understanding why the behavior is performed. Other segmentation techniques often do not provide information on the underlying process of the behavior. Therefore, campaigns based on attitude-based segmentation are considered as more advantageous (Haustein, 2011; Haustein and Hunecke, 2013; Hunecke et al., 2010; Li et al., 2013).

Various studies highlight the importance of market segmentation in the global field of transportation. Recent examples include Cools et al. (2009), Diana and Mokhtarian (2009a), Diana and Pronello (2010). With regard to public transit, Cronin and Hightower (2004) pinpointed market segmentation as one of the most valuable and useful marketing strategies in public transit organizations. Guiliano and Hayden (2005) described market segmentation as a profitable marketing strategy in order to increase transit ridership. In line with this, Beale et al. (2007) indicated that market segmentation is an effective approach to increase transit use without providing unwanted effects in other segments. In addition, Shiftan et al. (2008) applied attitudinal market segmentation in order to design more efficient transit services. Clustering was based on three attitudinal variables including sensitivity to time, need for fixed schedule, and willingness to use public transit. Also Chen and Chao (2011) stated the critical importance of targeting in marketing campaigns. In particular, they investigated switching intentions from private vehicle users toward public transit when introducing a mass rapid transit system. Their results indicated that it was important to target motorcycle users in marketing strategies due to their weaker influence of habit. Next to these traditional segmentations, Páez et al. (2012) applied segmentation of transit users as part of an innovative methodology to identify areas of higher or lower market potential around stations. In general, this methodology spots areas with a high exposure to travelers of a particular demographic profile which can be profitable to business in order to plan marketing, promotions and operations.

3. Data

3.1. Data Collection

To investigate the knowledge of the concept Light Rail Transit, data were collected by means of a self-reported questionnaire in Flanders, the Dutch speaking region in the northern part of Belgium (population around 6.2 million inhabitants). Because of the numerous advantages of web-based surveys, which have been well documented (Sperry et al., 2012; Wright, 2005), the questionnaire was mainly distributed on the internet. To overcome the potential sample bias caused by the underrepresentation of unemployed and lower income groups and the overrepresentation of young adults in web-based surveys, additionally traditional paper and pencil questionnaires were distributed. After all, literature (see e.g. Arentze et al. (2005); Fan and Yan (2010); Hart et al. (2012); Smith and Spitz (2010)) attributes this sample bias mainly to differences in internet access.

The survey was conducted on a person-based level and complete information of 492 respondents (aged 18 or older) was collected. The survey was divided into three main parts. The first part encompassed a personal questionnaire were various socio-economic indicators of the respondents were queried (e.g. age, gender, income, household size) as well as the use (in terms of frequency) of different transport modes. Moreover, the survey asked how often the respondents perform a work trip, a shopping trip and a leisure trip. These three types of trips were specifically queried since these are the most frequently performed trips according to the Flemish national travel survey. Cools et al. (2010) reported that they account for 50.5% of the trips made by the Flemish people. To limit response burden, other trip purposes like business trips and bring/get activities, were not considered. In addition, information on various socio-psychological factors was surveyed. Information regarding the attitudes towards various transport modes was collected, as well as the importance the respondent attributes to speed, convenience, cost, environmental friendliness and safety of a trip. Similarly, personal perceptions of comfort, cost, environment, safety and speed of a regional PT-trip (which was defined as a trip of 30km) were queried, as well as the perceptions of friends, family and colleagues. Note that a trip distance of 30km was chosen as reference, as this matches the aim of Light Rail Transit to provide transport services at a regional level. Finally, respondents' expected values of travel time, waiting time, access/egress time, cost and number of transfers for the 30km regional PT-trip were queried for respectively train, bus and LRT. Table 1 displays an overview of the variables collected in the personal questionnaire, together with their descriptions and the corresponding measurements units. Due to the large amount of variables in the survey, the table is confined to the variables that are included in the final models which are reported in the results section of this paper (Table 6 and Table 7).

The second part of the survey queried information about the perceived and revealed knowledge of LRT. Perceived knowledge was measured by the question "Do you exactly know the meaning of Light Rail Transit? (Yes/No)". Revealed knowledge was tested in two ways. First, respondents were confronted with a list of Public Transit pictures which contained a Light Rail system, a subway, a tram, a train and a trolley-bus. From this list, the respondents were asked to indicate the correct Light Rail system. Second, the respondents were asked to give their own worded definition of LRT. These definitions were compared to the definition as was established by the International Association of Public Transport (UITP) and were classified as correct or incorrect. The UITP defines Light Rail Transit as "*an electric rail-borne form of transport which can be developed in stages from a tramway to a rapid transit system operated partially on its own right-of-way. It stands midway between conventional urban tram systems at one extreme and heavy rail or underground metropolitan railway at the other.*"

Table 1: Overview of Variables included in the Final Models

Label	Definition	Measurement Unit
Age	Years passed since birth	< 40 years / > 40 years
Sex	Gender	Male / Female
Empl	Professionally active	No / Yes
Carposs	Possession of at least one car/van in the household	No / Yes
Bikeposs	Possession of at least one bike in the household	No / Yes
Wnract	Weekly number of out-of-home activities	Absolute values
Wnreduc	Weekly number of educational activities	Absolute values
Bikefreq	Frequent bicycle user (at least 4 times a week)	No / Yes
Impenv	Personal importance of trip being environmental sustainable	7-point Likert scale (1= very unimportant, …, 7 = very important)
Impcomf	Personal importance of trip being comfortable	7-point Likert scale (1= very unimportant, …, 7 = very important)
PPcar	Personal perception towards car	7-point Likert scale (1= very negative, …, 7 = very positive)
PPcomfort	Personal Perception of comfort of PT	7-point Likert scale (1= very negative, …, 7 = very positive)
PPcost	Personal Perception of ticket price of PT	7-point Likert scale (1= very negative, …, 7 = very positive)
ExpTrans	Does the traveler expect a transfer during LRT-use?	No / Yes
ExpSeatav	Does the traveler expect he/she can be seated during LRT-use?	No/Yes

The final part of the questionnaire contained a stated adaptation experiment in which the respondents had to indicate their preferred mode based on various system-specific attributes, including total travel time, access/egress time, waiting time, travel cost, transfers and seat availability. In total, each respondent was confronted with 24 hypothetical situations. Figure 1 displays an example of a hypothetical situation in the survey. It is noteworthy to mention that trip distance remained constant across the hypothetical situations. A detailed discussion of the results of this experiment is provided by Creemers et al. (2012).

You live in the center of a small city called 'A'. You want to perform a work activity. For this, you need to travel to the center of a larger city called 'B'. Both towns are 30km apart.
Which alternative do you prefer, given following trip characteristics.

	Alternative 1 Bus	Alternative 2 Light rail
Total Travel Time	43min – 59min	25min – 35min
Egress Time **Waiting Time**	5 min 6 min	5 min 5 min
Cost **Transfers** **Seats**	2 EUR No Free Seats	5 EUR Yes No Free Seats

O Bus O Light rail

Figure 1: Example of a hypothetical situation

The observations in the sample were weighted to achieve an optimal correspondence between the survey sample composition and the Flemish population. These weights are calculated by matching the marginal distributions of the sample and the population, based on the personal attributes age and gender of which perfect knowledge for Flanders is available (NIS, 2010). The weighted frequencies of the respondents' characteristics can be found in Table 2.

Table 2: Weighted Frequencies of Respondent Characteristics

Age class	Man	Woman	Total
18-24	5.1%	5.0%	10.1%
25-34	7.8%	7.7%	15.5%
35-44	9.4%	9.1%	18.5%
45-54	9.4%	9.1%	18.5%
55-64	7.6%	7.6%	15.2%
65+	9.6%	12.6%	22.2%
Total	48.9%	51.1%	100%

3.2. Descriptive Analysis

The results of the descriptive analysis of the survey are displayed in Table 3. From this table one can see that only a minority of the respondents (34%) stated they understand the meaning of the concept Light Rail Transit (perceived knowledge). For those respondents who claimed they had knowledge about the LRT-concept, also actual knowledge was tested. The results indicate that about 69.9% of the respondents were able to mark the correct picture with a Light Rail system. The remaining 30.1% who were unable to mark the correct picture, could be further subdivided into 6.7% who had absolutely no idea, 10.3% who indicated subway, 7.0% tram, 4.3% train and finally 1.9% trolley-bus. The second way of testing actual knowledge of the LRT-concept was by asking the respondent to provide a definition of LRT. Only 57% was able to give a (quasi-)correct definition of the concept LRT. Note that the definition was considered 'quasi-correct' if (some of) the following key-words (or their synonyms) were part of the respondent's definition: separate railway bedding, express tram, between tramway and train, regional transit system. Actual knowledge was not investigated for respondents who claimed they had no knowledge of LRT. This was a conscious choice, since the survey also contained a stated adaptation experiment as indicated in Section 3. Thus, it was necessary to acquaint the respondents with a correct definition of LRT such that they based their answers in the stated adaptation experiment on correct information.

Furthermore, Table 3 displays the share of respondents having overall actual knowledge, which is defined as respondents who marked the correct LRT-picture and provided a quasi-correct definition. Note that given the logic structure incorporated in the questionnaire, by definition these respondents also stated that they had knowledge about the LRT-concept. It is also noteworthy to indicate that respondents who indicated they had no knowledge are assumed to have no overall actual knowledge because of the definition acquaintance reported before. It is striking that 71% did not have any knowledge of the concept LRT and an additional 14% had only partial actual knowledge (indicated the correct picture or gave a quasi-correct definition, but not both). This implies that only 15% of the respondents know the true denotation of LRT. Finally, the cognitive mismatch, defined as the difference between the stated (perceived) knowledge and the overall actual knowledge, is quantified. The results indicate that 2 out of 10 respondents were subject to a cognitive mismatch. When the cognitive mismatch is assessed for respondents who stated they had knowledge of the LRT-concept, cognitive mismatch accumulated to 57% (=96.1/167.7).

Table 3: Descriptive Results of the Various Knowledge Levels

		Frequency	Percent
Stated/Perceived knowledge	Yes	167.7	34.1 %
	No	324.3	65.9 %
Actual knowledge (picture)	Yes	117.2	69.9 %
	No	50.5	30.1 %
Actual knowledge (definition)	Yes	95.4	56.9 %
	No	72.3	43.1 %
Overall actual knowledge	Yes	71.6	14.5%
	Partial	69.6	14.1%
	No	350.9	71.3%
Cognitive mismatch	Yes	96.1	57.3%
	No	71.6	42.7%

4. Modelling Methodology

To illustrate the importance of a deeper understanding of the factors influencing travelers' knowledge of the concept LRT, first, the impact of travelers' knowledge on modal choice is assessed. A suitable modeling technique to explore this relationship is the estimation of a negative binomial regression model. The response variable involves the number of times the respondent had chosen for the LRT-alternative in the 24 hypothetical situations, they evaluated in the survey. The negative binomial regression model can be defined as follow (Agresti, 2002):

$$\log(Y) = \alpha + \beta_1 x + ... + \beta_k x_k , \quad (1)$$

where Y equals the response variable, α denotes the intercept, β_k the model parameters to be estimated and x_k the explanatory variables.

Secondly, the different determinants of the level of knowledge of the concept LRT are analyzed, thereby making a distinction between determinants influencing the overall actual knowledge and the determinants influencing a cognitive mismatch between perceived and actual knowledge. Since overall actual knowledge has multiple possible discrete outcomes (Full(Yes)/Partial/No), the most appropriate model to estimate is the Multinomial Logit Model (MNL-model), for which the mean response is modeled as (Agresti, 2002):

$$\pi_i(j) = \frac{\exp(\alpha + \beta_1 x + ... + \beta_k x_k)}{\sum_{j \in J} \exp(\alpha + \beta_1 x + ... + \beta_k x_k)}, \quad (2)$$

where $\pi_i(j)$ is the probability for individual i to choose alternative j from the choice set J.

Finally, the cognitive mismatch has a binary outcome (Yes/No), and therefore the most suited modeling technique is the binary logit model. The binary logit model can be considered as a simplified case of the MNL-model where the response variable has only two categories. The mean response can be defined as (Molenberghs and Verbeke, 2005)

$$\log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha + \beta_1 x + ... + \beta_k x_k, \quad (3)$$

where $\frac{\pi(x)}{1-\pi(x)}$ denotes the odds. The unknown parameters are attained by maximizing the log likelihood using a ridge-stabilized Newton-Raphson algorithm.

In total, three models are estimated: (1) to explore the role of knowledge on modal choice, (2) to identify the determinants of the overall actual knowledge and (3) to identify the determinants of a cognitive mismatch. The models were constructed by applying backward selection to find the most relevant variables in the model, with a 10% level of significance to remain in the model. The final models were checked for multicollinearity to ensure the reliability of the parameter estimates. Multicollinearity was assessed using Variance Inflation Factors (VIF). The results of the analysis do not indicate problems of multicollinearity (all VIFs smaller than 2). The outcome of the model estimations are presented in the next sections.

5. Model Estimation Results and Discussion

5.1 Impact of knowledge on LRT-preference

Table 4 shows the results of the negative binomial regression model to indicate the relationship of travelers' knowledge on modal choice (Model 1). Recall from the methodology section that the response variable equals the number of times the LRT-alternative was chosen by the respondent in the 24 hypothetical situations. The explanatory variable in the model is related to the various levels of knowledge based on stated knowledge (yes/no) and actual knowledge (neither photo or definition correct, photo or definition correct, photo and definition correct). One could derive from the table that travelers with no stated knowledge and travelers with stated knowledge but no actual knowledge are less intended to choose LRT compared to the reference category of travelers who have overall/full actual knowledge. Moreover, the result of an additional likelihood ratio test shows that the parameter estimates for travelers not having stated knowledge and travelers having stated knowledge but no actual knowledge are not significantly different from each other (P-value = 0.23), implying that both categories of knowledge have the same impact on LRT-preference.

Table 4: Models Parameter Estimates for determining the impact of knowledge on modal choice

Parameter		Overall actual knowledge			
	Level	Estimate	S.E.	P-value	Sign.
Intercept	/	2.6355	0.0308	<.0001	***
Level of knowledge	No stated/perceived knowledge	-0.1288	0.0351	0.0002	***
	Stated knowledge, but no actual knowledge	-0.2176	0.0852	0.0106	*
	Stated knowledge, partial actual knowledge	-0.0321	0.0491	0.5126	ns.
	Stated knowledge, full actual knowledge	/	/	/	/

It could be concluded from the descriptive analysis (Section 3.2) that Flemish people have a major lack of knowledge of the concept LRT. This can lead to sub-optimal travel decisions, which is confirmed by the modeling results in Table 4. These results underline the significant effect of knowledge of the concept LRT on mode choice and thus acknowledge the importance of a deeper understanding of the determinants influencing the level of knowledge.

5.2 Factors influencing travelers' knowledge

5.2.1 Overall Results

Table 5 displays the results of the overall significance tests for the overall actual knowledge (Model 2) and the cognitive mismatch model (Model 3). The results show that socio-economic variables as well as various socio-psychological variables are significantly contributing to both the (overall) actual knowledge and the cognitive mismatch. In general, one could derive that socio-economic variables are more influential than the socio-psychological variables (smaller P-values). Notwithstanding, all identified factors are important when developing marketing campaigns to raise the state of knowledge among the Flemish population.

Regarding the socio-economic determinants, employment turns out to be the most important determinant when modeling the cognitive mismatch (smallest p-value), while gender is the most influencing determinant of actual knowledge. In addition, other significant socio-economic determinants in both models are car and bike possession, delineating the travel options of the traveler. Moreover, the results from the actual knowledge model show that also the respondent's current bike use and the number of weekly out-of-home activities significantly affect the actual understanding of the concept LRT. The significance of bike use can be accounted for by the fact that it is to some extent an expression of environmental awareness.

Concerning the socio-psychological variables investigated, the traveler's perceived perception of comfort and ticket price of PT and the traveler's expectations with regard to the Level Of Service of a LRT-trip (in particular: transfers and seat availability) are significant determinants in both models. Perception of ticket price of PT even appears the most influencing socio-psychological determinant in the overall actual knowledge model (smallest P-value), while in the cognitive mismatch model expectations with regard to seat availability in the LRT-vehicle is the most influential. In addition, the travelers' importance attached to the trip being environmental sustainable and the importance attached to the comfort level of the trip are significant variables influencing the overall actual knowledge. Finally, the travelers' perception towards the car significantly impacts the overall actual knowledge.

The above findings are confirmed by literature, which shows that the identified socio-economic and socio-psychological determinants in the models are common characteristics for market segmentation in the field of transportation, as expounded in Section 2.2.

Table 5: Results of the Overall Significance Type III-test

	Overall actual knowledge				Cognitive mismatch			
Parameter	**DF**	**Chi^2**	**P-value**	**Sign.**	**DF**	**Chi^2**	**P-value**	**Sign.**
Socio-economic variables								
Age	2	8.6528	0.0132	**	1	/	/	/
Sex	2	23.0279	<.0001	***	1	/	/	/
Empl	2	10.3035	0.0058	***	1	23.6391	<.0001	***
Carposs	2	5.6370	0.0597	*	1	5.4357	0.0197	**
Bikeposs	2	4.6245	0.0990	*	1	8.1003	0.0044	***
Bikefreq	2	8.0486	0.0179	**	1	/	/	/
Wnreduc	2	/	/	/		10.7220	0.0011	***
Wnract	2	12.7510	0.0017	***	1	10.8661	0.0010	***
Socio-psychological variables								
Impenv	2	4.9415	0.0845	*	1	/	/	/
Impcomf	2	5.9646	0.0507	*	1	/	/	/
PPcar	2	8.5545	0.0139	**	1	/	/	/
PPcomfort	2	5.7904	0.0553	*	1	5.6877	0.0171	**
PPcost	2	11.1549	0.0038	***	1	2.8431	0.0918	*
ExpTrans	2	5.2495	0.0725	*	1	5.7714	0.0163	**
ExpSeatav	2	5.1969	0.0744	*	1	5.9093	0.0151	**

* P-value <0.10, ** P-value < .05, *** P-value < 0.01

5.2.2 Parameter estimates

The parameter estimates and corresponding standard errors for the actual knowledge model are shown in Table 6. Full actual knowledge of the concept LRT (photo and definition correct) was selected as the reference case. Consequently, the displayed parameter estimates in the table correspond to the two remaining stages of knowledge (no knowledge and partial knowledge). The parameter estimates for the cognitive mismatch model are shown in Table 7. The estimated parameters should be interpreted in terms of odds ratios (ORs), or according to the sign of the parameter.

With respect to age, one could derive from Table 6 that the odds of not having knowledge decreases with 58.29% (=exp(-0.8745)-1) for travelers younger than 40 years and the odds of having partial knowledge with 60.94%, compared to travelers older than 40 years. This implies that the probability of full actual knowledge of LRT is significantly higher in the youngest age group and that people above 40 years of age are more likely to have less understanding of the concept LRT. Several explanations can be formulated to explain the role of age. First, the degree of habitual behavior among older persons is higher, which forms a threshold for new transport options (see Section 2). Older people are more conservative and reserved for new technology. Second, young persons are more familiar with new and modern media like smart-phones, facilitating the wide-spread access to real-time information sources such as news bulletins. Consequently, young persons are more acquainted with the planned LRT-projects. Third, the use of the English term “Light Rail Transit” can also be a barrier in the acquisition of knowledge for elderly, since they are less confident with this language.

Table 6: Model Parameter Estimates, standard errors and OR for the actual knowledge model

	No knowledge			Either photo or definition correct		
Parameter	**Estimate**	**S.E.**	**OR**	**Estimate**	**S.E.**	**OR**
Socio-economic variables						
Intercept	4.2359	1.9617	68.1239	-1.0079[1]	2.9177	-0.6350
Age (< 40)	-0.8745	0.3080	-0.5829	-0.9401	0.4077	-0.6094
Sex (Male)	-1.0958	0.3254	-0.6657	0.1765[1]	0.4195	0.1930
Empl (Yes)	-0.8769	0.3559	-0.5839	-1.4031	0.4424	-0.7542
Carposs (Yes)	1.0730[1]	0.7351	1.9241	3.9165	1.7293	49.2244
Bikeposs (Yes)	-1.4896	0.6965	-0.7745	-1.2940[1]	0.8223	-0.7258
Bikefreq (Yes)	-0.5791	0.3469	-0.4396	0.2761[1]	0.4188	0.3180
Wnract	0.1039	0.0301	0.1095	0.1130	0.0326	0.1196
Socio-psychological variables						
Impenv	0.0144[1]	0.1171	0.0145	-0.2415[1]	0.1487	-0.2146
Impcomf	-0.0178[1]	0.1560	-0.0176	0.4560	0.2297	0.5778
PPcar	0.1475[1]	0.1338	0.1589	-0.2415[1]	0.1642	-0.2146
PPcomfort	-0.2195	0.1291	-0.1971	-0.3860	0.1605	-0.3202
PPcost	-0.1505[1]	0.1140	-0.1397	0.2378[1]	0.1508	0.2685
ExpTrans (Yes)	0.00993[1]	0.3253	0.0100	-0.8575	0.4584	-0.5758
ExpSeatav (Yes)	-0.8673	0.5082	-0.5799	-1.4151	0.6208	-0.7571

[1] Not significant at the 0.1 level

Next to age, gender also contributes significantly to the level of knowledge. Males are less likely of having no knowledge in comparison to females, while no significant difference between males and females could be found for the partial level of knowledge. The significant gender effect can be explained by the fact that males generally express greater interest in technology and are therefore more susceptible to innovations. Consequently, they will quickly become acquainted with this new form of public transit.

Being employed decreases the odds of having no knowledge of LRT with 58.39% and decreases the odds of having only partial knowledge with 75.42%, implying that employed people have higher probabilities on full actual knowledge. In line with these results, the parameter estimate in the cognitive mismatch model (Table 7) shows a lower probability on a cognitive mismatch for employed people.

With regard to car ownership and bike ownership in the household, it appears that bike ownership is associated with lower probabilities of not having any kind of knowledge, while car ownership is associated with increased probabilities of not having overall knowledge (although not significant in the no knowledge case). Yet again, the results of the cognitive mismatch are in the same line. The probability of a cognitive mismatch is positively associated with car ownership and negatively related to bike ownership. A possible reason for this effect is that bicycle ownership could be seen as a proxy for environmental awareness which increases the interest in (innovative) sustainable transport modes such as LRT, while car ownership enhances car use and consequently diminishes the interest in more sustainable forms of transport. This reasoning is confirmed by the parameters estimates of bike frequency, which indicate that frequent bike users are more likely to have at least some level of knowledge of the LRT-concept. Finally, it appears that every additional out-of-home activity increases the odds of having no knowledge with 10.95% and increases the odds of having partial knowledge with 11.96%.

Table 7: Model Parameter Estimates, standard errors and OR for the cognitive mismatch model

Parameter	Estimate	S.E.	OR
Socio-economic variables			
Intercept	1.4402[1]	2.2639	3.2215
Empl (Yes)	-2.4670	0.5074	-0.9152
Carposs (Yes)	4.3425	1.8626	75.8995
Bikeposs (Yes)	-2.8978	1.0182	-0.9449
Wnract	0.1386	0.0420	0.1487
Wnreduc	-2.6133	0.7981	-0.9267
Socio-psychological variables			
PPcomfort	-0.4029	0.1690	-0.3316
PPcost	0.2339	0.1387	0.2635
ExpTrans (Yes)	-1.2211	0.5083	-0.7051
ExpSeatav (Yes)	-1.6911	0.6957	-0.8157

[1] Not significant at the 0.1 level

Besides, it can be derived from Table 6 that the more importance the traveler attributes to the comfort level of PT, the higher the likelihood of having partial knowledge will be. Related to this effect, it appears that when the traveler perceives PT as comfortable, the likelihood of having no knowledge and the likelihood of having only partial knowledge decreases. In accordance, the results of the cognitive mismatch model (Table 7) show that the traveler's perception of PT being comfortable is negatively associated with the likelihood on a cognitive mismatch.

Concerning the perception towards car, it is shown that a positive perception is associated with an increase in the odds of having no knowledge at all and a decrease in the odds of having at least some (partial) knowledge of the concept LRT. A possible explanation for this effect is that a positive perception towards car encourages actual car use and consequently declines the interest in more sustainable transport forms. The parameter estimates of the expectations of the traveler with regard to LRT-use show that when the traveler expects that he/she can be seated will increase the likelihood of overall actual knowledge. In addition, if the traveler expects a transfer during LRT-use it will negatively influence the probability of having at least some (partial) knowledge. With regard to the cognitive mismatch model, the parameter estimates show that expected transfers and expected seating on the LRT-vehicle will decrease the probability on a cognitive mismatch.

Overall, one can conclude from the parameter estimates of the socio-psychological variables that travelers who are in general more negative towards public transport (with regard to comfort, ticket price, expectations of LOS) and more positive towards car (perception towards car) are more likely to have no knowledge or are more likely to have only partial knowledge of the concept LRT.

6. Conclusions and Policy Recommendations

In this paper, various levels of knowledge of the concept LRT were explored. The results revealed a serious lack of knowledge of Flemish people regarding the basic characteristics of LRT. Literature (e.g. Dziekan and Dicke-Ogenia, 2010) describes that such lack of knowledge can lead to sub-optimal travel decisions which generally limit the use of sustainable transport modes. This was confirmed in the current research by exploring the role of knowledge of the concept LRT on LRT-preference. The results indicated that having no knowledge at all will lower the probability for LRT-preference. Consequently, a successful implementation of a LRT-system might be jeopardized and thus it is of crucial importance to raise the level of knowledge. According to the literature review, raising the level of knowledge can be achieved in two ways. A first option is based on increased transit experience (e.g. Brög, 2002; Dziekan, 2008; Pedersen et al., 2011). Dziekan (2008) showed that knowledge of an unfamiliar transit system was acquired very quickly in the first days of using that system and that gaining experience remedied misperceptions. In this perspective, marketing actions like offering free PT for a certain time period can be worthwhile when implementing a new Light Rail system. Notwithstanding, it should be noted that such offerings can be very costly. Second, it is important to provide information to the traveler by contriving information campaigns (e.g. Beale et al., 2007; Chorus et al., 2007; Diana, 2010). These campaigns are most efficient if they are fine-tuned according to the principles of market segmentation. To explore how information campaigns should be constructed and which target groups should be approached, the paper explored socio-economic and socio-psychological determinants of the (overall) actual knowledge and the determinants influencing a cognitive mismatch. From the models it was concluded that campaigns should target older people, females, unemployed and car-owners. With regard to the socio-psychological variables, one should take into account travelers' perceptions with regard to comfort and ticket price of PT, and the traveler's expectations with regard to the LOS of a LRT-trip.

Besides, the results indicated that young people are more likely to have knowledge of the concept LRT than older people. However, it is noteworthy to mention that the temporal transferability of these conclusions is not necessarily guaranteed. Currently young people are the elderly of the future, implying the elderly of today do not necessarily behave the same as the elderly of tomorrow (Arentze et al., 2008).

Finally, it should be stressed that after general knowledge of LRT is acquired, knowledge acquisition of LRT should shift towards the highest hierarchical level, as described in Dziekan (2008) and expounded in Section 2. In this context, providing information to the traveler again plays a crucial role. The traveler should be sufficiently supported by means of personalized real-time journey planners, general information of available services and real-time multi-modal information displays to reduce the cognitive effort when making the trip. Especially mobile information systems can play a crucial role in this (Zhang et al., 2012).

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