Transportation Research Part A 46 (2012) 1490–1505

Contents lists available at SciVerse ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Effects of different factors on drivers' guidance compliance behaviors under road condition information shown on VMS

Shiquan Zhong, Lizhen Zhou *, Shoufeng Ma, Ning Jia

College of Management and Economics, Tianjin University, No. 92 Weijin Road, Nankai District, Tianjin 300072, China

ARTICLE INFO

Article history:
Received 16 September 2011
Received in revised form 29 April 2012
Accepted 16 May 2012

Keywords:
VMS
Compliance behavior
Influencing factors
Ordinal regression
Guidance mode

ABSTRACT

It is generally accepted that compliance behavior is affected by many factors. The purpose of this study is to investigate the effects of diverse factors on drivers' guidance compliance behaviors under road condition information shown on graphic variable message sign (VMS), and based on this to find out a better information release mode. The involved data were obtained from questionnaire survey, and ordinal regression was used to analyze the casual relation between guidance compliance behavior and its influencing factors. Based on an overall analysis of conditions in driver's route choice, an accurate method was proposed to calculate the compliance rate. The model testing information indicated that ordinal regression model with complementary log–log being the link function was appropriate to quantify the relation between the compliance rate and the factors. The estimation results showed that age, driving years, average annual mileage, monthly income, driving style, occupation, the degree of trust in VMS, the familiarity with road network and the route choice style were significant determinants of guidance compliance behavior. This paper also compared two different guidance modes which were ordinary guidance mode (M1) and predicted guidance mode (M2) through simulation. The average speed fluctuations and average travel time supported that M2 had better effect in improving traffic flow and balancing traffic load and resource. Some detailed suggestions of releasing guidance information were proposed with the explanation by flow-density curve and variation of traffic flows. These findings are the foundation to design and improve guidance systems by assessing guidance effect and modifying guidance algorithm.

1. Introduction

Urban traffic guidance system, which can efficiently alleviate traffic congestion and greatly improve the performance of traffic system, is a great part of intelligent transport system (ITS). Variable message sign (VMS), as an infrastructure of urban traffic guidance system, is a main platform to release guidance information. VMS can provide drivers with traffic information, including road conditions, abnormal traffic events, and traffic safety campaigns, by gathering, processing and disseminating dynamic and nearly real-time traffic information. Meanwhile, releasing traffic information is also a means of traffic dispersion, which can guide drivers to avoid congested roads, balance the traffic load on network and make the best use of roads resource.

Nevertheless, unlike traffic control signal, the guidance information is just a kind of suggestion message, and it has no mandatory effect on drivers. So drivers can choose to comply with the VMS or not. Compliance rate is used to represent the drivers' compliance degree on guidance information. The rate is the proportion of drivers who select the suggested roads

* Corresponding author. Tel./fax: +86 22 2740 4446.
E-mail addresses: shiquantju@yahoo.com.cn (S. Zhong), zhoulizhentju@yahoo.com.cn (L. Zhou), sfma@tju.edu.cn (S. Ma), ghost9090@163.com (N. Jia).

0965-8564/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tra.2012.05.022

of VMS just because of the existence of VMS, and it reflects the effects of guidance information on drivers' compliance behavior. In this paper, compliance rate is the probability of drivers selecting the suggested roads among their multiple selections.

In previous studies, drivers were generally assumed to comply with guidance information completely (Ericsson et al., 2006; Fu, 2001; Kanafani and Al-Deek, 1991; Lo and Szeto, 2002; Piyushimita and Ashish, 1996; Wang et al., 2006) or select paths according to a fixed rate (Francesco, 2003; Mammar et al., 1996; Papageorgiou, 1990; Yin and Yang, 2003), this is not realistic. Many researches declared that drivers preferred the information about accident, congestion or alternative routes, but the proportions of drivers who really changed routes were distinct, rarely more than 40%. Cummings (1994) found only 4–7% of the drivers chose to switch routes, Lindkvist (1995) found 5–25% of the drivers chose the alternative routes, Ramsy and Luk (1997) found the switching rate reached to 30% when traffic congestion information was released, Davidsson and Taylor (2003) found 6–41% of the drivers would choose alternative roads to avoid congestion in Sweden. Compliance rate varied significantly as the compliance behavior of drivers closely depended on their characteristics, their perception of the guidance information, the information content, their familiarity with road network, and even their mood when they saw the VMS. Furthermore, the dependency changed gradually while the drivers gained more knowledge of VMS (Adler et al., 1993; Bonsall, 1992a; Bonsall and Palmer, 1998; Bonsall and Parry, 1990; Chen et al., 1999; Khattak et al., 1991; Lai And Yen, 2004; Chen and Mahmassani, 1993; Yang et al., 1993). A known compliance rate was the foundation of effective traffic guidance system, thus it was very important to study the factors that affected the perception and guidance compliance behavior of drivers (Koutsopoulos and Xin, 1993; Ozbay and Bartin, 2004).

Bonsall (1992a) proposed that individual route choice was affected by a number of factors, including expected journey time, delays, congestion, information-related routes, costs, safety and security hazards, the familiarity with the routes and information quality. Bonsall and Palmer (1998) demonstrated that information about accidents, delays and congestion shown on VMS had a significant influence on route choice, and the influence was very dependent upon the wording of the message. Lai and Yen (2004) conducted a questionnaire survey to investigate drivers' attention, preference and the response to VMS, the results indicated that 69.23% of the drivers were aware of the existence of VMS while they were driving. The display characteristics, such as font, color and phrasing, and the socio-economic characteristics, such as age, gender and education, were significant factors which influenced drivers' preference and response. Yang et al. (2005) carried out an ergonomic study to assess drivers' response and preference to different information characteristics, the results indicated that a combination of three colors on VMS took longer time to respond than one or two, and drivers preferred to yellow, green or yellow and green.

Most previous researches focused on pure text-based VMS (Anttila et al., 2000; Cooper et al., 2004; Dutta et al., 2004; Erke et al., 2007; Rämä and Kulmala, 2000; Wardman et al., 1997). Dutta et al. (2004) conducted a driver simulator study with two consecutive screens presenting text messages in the USA. The messages were repeated or not, the presentation time was 0.5 s per word for repeated messages and 1 s for unrepeated ones. The result indicated that the miss rate of unrepeated messages was significantly higher than the repeated ones. Cooper et al. (2004) reported about a study on text messages involved numerals carried out in England. A text message with a certain font and capital height had low legibility, widening the spacing between the numerals or using the different numeral fonts could increase the legibility. The legibility was also enhanced when difficult words were shown in another format, such as upper case letters, or using a pictogram instead the difficult words.

Compared to the text-based VMS, fewer researches about symbolic and graphic VMS were conducted (Alferdinck et al., 1998; Choi and Tay, 2008; Luoma and Rämä, 2001; Tay and Choi, 2009). Luoma and Rämä (2001) interviewed 795 voluntary drivers from six countries including England, Finland, France, Germany, Greece and Netherland on graphic VMS. The results showed that age, gender and driving experience had no significant effect on interpreting the VMS, whereas country had. It might be due to the diversity of graphic VMS in different countries. Tay and Choi (2009) redesigned the graphics of traffic control information in Seoul of Korea and presented them on VMS to test and assess. They found out that most of the graphics were easy to understand, but some were not, such as the graphics of traffic accidents, congestion and snow information. Furthermore, some scholars compared the effects of text-based and graphic VMS on drivers' behaviors (Kosonen and Luoma, 1994; Nuttall et al., 1998; Rämä et al., 2004). Kosonen and Luoma (1994) compared wet road surface information shown on text-based and graphic VMS to determine what kind of VMS should be used. Rämä et al. (2004) found graphic VMS was preferred by drivers despite they might not understand it correctly. Nuttall et al. (1998) pointed out the recognition process of symbols or graphics was very different from characters, it took drivers more attention and longer distance to read text messages.

Graphic VMS is used widely in practice (Balz, 2003; Sara and Gabriel, 2007; Stainforth, 2004). Western European Road Directors and Deputies (WERD) was in favor of a set of common graphic VMSs being used in European countries (Stainforth, 2004). Conference of European Directors of Roads (CEDR) suggested that some new and sufficient graphic VMSs should be used in certain situations. Balz (2003) proposed to use easy-to-understand symbols and pictograms as much as possible in some areas for harmonization. Language-independent was the advantage of symbols and pictograms. It allowed drivers from different countries to read, of course, pure graphic information was not enough sometimes, especially when the notification was presented, and supplementary text information might be needed (Sara and Gabriel, 2007).

Owing to the significant difference between the effects of text-based and graphic VMSs on drivers' behaviors, the findings of text-based VMS research cannot be immediately applied to design and use the graphic VMS, it was necessary to study the graphic VMS separately. The aim of this research was to study the effects of different factors on drivers' guidance compliance behaviors under road condition information shown on graphic VMS and find out a better information release mode.