



The relation between the perception of safe traffic and the comprehension of road signs in conditions of ambiguous and redundant information

Sigal Kaplan^{a,b}, Shaun Bortei-Doku^b, Carlo G. Prato^{c,*}

^a Department of Geography, Hebrew University of Jerusalem, Mount Scopus, 91905 Jerusalem, Israel

^b Department of Management Engineering, Technical University of Denmark, Bygningstorvet 116B, Kgs Lyngby 2800, Denmark

^c School of Civil Engineering, The University of Queensland, St. Lucia 4072, Brisbane, Australia



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ABSTRACT

This study proposes the investigation of the relations between the perception of safety improvement, the provision of information with road signs, the amount of provided information, and observable and unobservable traits of road users. A web-based survey collected information about the estimation of conflicts and the perception of safety improvement in 12 traffic locations grouped according to (i) low amount of information that generated ambiguity and (ii) high amount of information that generated redundancy. Moreover, the web-based survey gathered information about socioeconomic characteristics, driving frequency, driving habits, driving style and need of closure of road users, the latter being measured with two validated psychometric scales. The survey was administered to 753 Hungarians with expertise in transport and traffic (for the purpose of having a good estimation of safety improvements) and experience with redundant information (for the purpose of having a sample familiar with one of the issues). A Structural Equation Modelling approach allowed estimating a system of relations that suggested the following: (i) the perception of safety improvement is not related only to road sign comprehension, but also to the amount of information and, more relevantly, the driving style and the information processing needs of the drivers; (ii) the perception that road signs improve safety varies with gender, age, driving frequency and driving habits, thus making the purpose of road signs to reduce conflict a more complex task because of the effect of the traits of the road users; (iii) the road design should adhere to three of the principles of sustainable safety that have been proposed to design self-explanatory roads; (iv) solutions should look into personalised driving assistance that would be able to address the different needs that drivers have to feel safe.

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1. Introduction

Road conflicts and crashes are responsible for a large amount of serious and fatal injuries that are ascribed to behavioural causes in the vast majority of the cases (see, e.g., Petridou & Moustaki, 2000; Rothengatter, 1997; Shinar, 2007). Road signs

* Corresponding author.

E-mail addresses: sigal.kaplan@mail.huji.ac.il (S. Kaplan), shaundoku@hotmail.com (S. Bortei-Doku), c.prato@uq.edu.au (C.G. Prato).

are responsible for regulating traffic and reducing conflicts, although clearly their efficacy depends on the ability of road users to comprehend the signs.

In 1968, the United Nations agreed in principle on common marking configurations, layout designs, colour schemes and sign shapes. However, road agencies worldwide have applied different rules that diverge on configurations and layouts, colour schemes and placement principles, and even maximum number of signs allowed on a single pole. These different rules might lead to providing either a low amount of information, which can cause ambiguity in the interpretation of the traffic situation, or a high amount of information, which can cause redundancy and consequently inattention in the reading of the traffic situation.

Research has usually focused on the effect of configurations and layouts on road sign comprehension. Results have revealed the importance of road signs to adhere to ergonomic principles in order to increase comprehensibility that is related to spatial compatibility, conceptual compatibility, physical representation, familiarity, and standardization (Ben-Bassat & Shinar, 2006; Ng & Chan, 2008; Shinar, Dewar, Summala, & Zakowska, 2003; Shinar & Vogelzang, 2013). Research has also shown that sign conspicuity stimulates attention and consequently increases comprehensibility (Charlton, 2006; Macdonald & Hoffmann, 1991; Summala & Hietamaki, 1984), and sign placement plays a central role in capturing attention from drivers (Borowsky, Shinar, & Parmet, 2008; Liu, 2005; Zhao, Wu, Rong, & Ma, 2015). However, research has also indicated that an excess of information causes lack of attention because drivers need to process too many stimuli (Castro, Moreno-Rios, Tornay, & Vargas, 2008; Liu, 2005; Liu, Sun, & Rong, 2011) and end up forgetting most of the signs seen while driving (Costa et al., 2014). Drivers might also be distracted by commercial advertisement alongside road signs that contributes to an increase in the amount of information (Edquist, Horberry, Hosking, & Johnston, 2011; Metz & Krüger, 2014; Young et al., 2009). Lastly, context plays a significant role although some studies reported a positive role in increasing comprehension of signs (Ben-Bassat & Shinar, 2015; Shinar et al., 2003; Silver et al., 1995; Wolff & Wogalter, 1998), while others mentioned that the lack of context made drivers confused or less attentive (Silver et al., 1995; Summala & Hietamaki, 1984).

Research has also concentrated on the effect of driver characteristics on road sign comprehension. Results have produced contrasting messages about the effect of age on road sign comprehension, as some studies reported differences not being significant between younger and older drivers (Ben-Bassat & Shinar, 2015; Dewar, Kline, & Swanson, 1994; Scialfa et al., 2008; Shinar et al., 2003), while other studies mentioned younger drivers being better in interpreting correctly road signs (Al-Madani & Al-Janahi, 2002; Bortei-Doku, Kaplan, Prato, & Nielsen, 2017; Macdonald & Hoffmann, 1991) and especially in understanding particular symbols (Liu & Ho, 2012; Shinar et al., 2003). Apart from age, only two studies looked into gender to show that males have better road sign comprehension (Al-Madani & Al-Janahi, 2002; Bortei-Doku et al., 2017) and only one study investigated socioeconomic status differences to find that drivers who are better educated and have higher income are better in interpreting correctly road signs (Al-Madani & Al-Janahi, 2002).

Existing research focused on the factors behind road sign comprehension under the implicit assumption that increasing comprehension implies perceiving the traffic as safer. Also, existing research analysed heterogeneity in road sign interpretation under the implicit assumption that processing information relates mainly to gender and age. Lastly, existing research relied on statistical analysis under the implicit assumption that the relations are linear and in particular the relations between amount of information and perception of safety does not require further investigation. This study relaxes these three implicit assumptions by investigating whether the perception of safe traffic relates to road sign comprehension while controlling for the amount of information as well as observed and unobserved traits of road users. Specifically, this study proposes a multivariate modelling approach that relates the perception of safe traffic to ambiguity and/or redundancy in the information, observed characteristics of road users, and unobserved traits of road users with particular attention to driving style and information processing. On the one hand, this study looks at driving style given the consideration that too little or too much information might stimulate ambiguous interpretation that lead to uncertainty that might trigger coping mechanisms such as distracted or aggressive driving (Gwyther & Holland, 2014). On the other hand, this study looks at the need for closure given the consideration that it is linked to the way individuals recall information (Dijksterhuis, van Knippenberg, Kruglanski, & Schaper, 1996), process information (Kossowska & Bar-Tal, 2013) or deal with uncertainty (Czernatowicz-Kukuczka, Jaśko, & Kossowska, 2014).

Given these premises, this study analysed the responses of a large sample of Hungarian transport professionals who participated in a web-based survey. Survey participants were required to observe the photographs of 12 traffic locations divided in two groups where two variations of each location was presented: the first group presented a first configuration leading to ambiguity about the allowed manoeuvres, followed by a second configuration where the provision of information removed the ambiguity; the second group presented a first configuration without road signs, followed by a second configuration where the provision of additional information allowed for the evaluation of possible redundancy. Survey participants were requested not only to comprehend the allowed manoeuvres and to estimate the number of conflicts in the first configuration, but also to indicate their perception of safety improvement with the added information in the second configuration. Alongside this exercise, survey participants were asked to provide socioeconomic characteristics and to fill the Multidimensional Driver Style Inventory (MDSI, Taubman - Ben-Ari, Mikulincer, & Gillath, 2004) and the Need for Closure Scale (NFCS, Roets & van Hiel, 2011; Webster & Kruglanski, 1994). The experiment focused on Hungarians, as road users familiar with road environments with variable amount of information, and transport professionals, as experts able to evaluate the conflicts and to assess the perception of safety improvements. Structural Equation Modelling (SEM) was used to relate the perception of safety improvement with the observed and unobserved traits of the survey participants as well as the estimate of the number of assessed conflicts without road signs. The simultaneous estimation of the system of equations is the first in the field of

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