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Examination of driver detection of roadside traffic signs and advertisements using eye tracking

Darja Topolšek [a,*], Igor Areh [b], Tina Cvahte [a]

[a] University of Maribor, Faculty of Logistics, Slovenia
[b] University of Maribor, Faculty of Criminal Justice and Security, Slovenia

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ABSTRACT

Research shows that driver factors, particularly driver distraction, are the most common cause of traffic accidents. Among various visual distractions, objects such as advertisements that are commonly prevailing elements at the roadside, represent an important external distractor that may affect driving performance. Research findings on the influence that roadside signs or advertisements have on driver's attention focus are not consistent. Therefore, with the application of eye-tracking technology, this research was designed to test several assumptions regarding drivers' detection and perception of roadside elements. Seventeen volunteer participants, 19–76 years old, performed ten kilometres of urban driving, in which they were visually challenged with 56 traffic signs and 31 advertisements. It was found that drivers' age is not associated with the number of roadside objects detected. Those drivers who detected more traffic signs were also more attentive to visual advertisements. Furthermore, a positive and large effect size between the number of detected street-level and raised-level advertisements was also found.

1. Introduction

Different factors affect the occurrence of traffic accidents, which are derived from three areas: the environment, the vehicle and the driver. The driver can make a variety of errors. Driver distraction, as an acknowledged safety problem with serious consequences (Strayer, Drews, & Crouch, 2006), is one of those errors which Olson, Hanowski, Hickman, and Bocanegra (2009) define as a distraction occurring in the event of inattention that causes a delay in the recognizing of information, needed to safely perform a driving task. Lansdown, Stephens, and Walker (2015) emphasize that there is no currently valid common definition of driver distraction, but assess that the most appropriate definition would be that of Hedlund, Simpson, and Mayhew (2005), who define distraction as an occurrence involving a diversion of attention of the driver due to the fact that the driver temporarily focuses on something (an object, person, task or event) that is not related to his driving, which consequently reduces his awareness, decision-making ability and performance, which leads to a higher risk of the need for corrective actions, near-crashes and crashes. A study by Wang, Knipling, and Goodman (1996) show that 25–30% of crashes can be attributed to driver distraction; other researchers claim that this number can be as high as 35–50% or even up to 80% (Sussman, Bishop, Madnick, & Walter, 1985; Dingus et al., 2006; Robertson, 2011; Wang et al., 1996). Research by the National Highway Traffic Safety Administration of the USA (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006) examines the behaviour of drivers during driving and reveals that 78% of all crashes, 65% of near crashes and jointly 73% of all events

* Corresponding author.
E-mail addresses: darja.topolsek@um.si (D. Topolšek), igor.areh@fvv.uni-mb.si (I. Areh), tina.cvahte@fl.uni-mb.si (T. Cvahte).

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out of the 20,000 examined contained some form of inattention. Due to these facts, research on driver distraction and driver errors is currently of utmost interest (Donmez & Liu, 2015; Ferdinand & Menachemi, 2014; Lansdown, 2012; Salmon, Lenne, Stanton, Jenkins, & Walker, 2010; Talbot, Fagerlind, & Morris, 2013; Young & Lenné, 2010; Young & Salmon, 2012), but nonetheless remains under-researched in Europe (Talbot et al., 2013) with some rare noted exceptions (e.g. Sullman, 2012).

Most contemporary research is focused on individual distracting elements and does not consider the drivers' environment as a whole and the distracting elements as a part of it. McEvoy, Stevenson, and Woodward (2006) conducted research based on a survey of 1347 licensed drivers aged between 18 and 65 years, and they note that in evaluations of their most recent driving trip with a duration of five minutes or less, the drivers identified the following most disturbing factors (ordered by importance): lack of concentration, adjusting in-vehicle equipment, viewing outside people, objects, or events, and talking to passengers. Lansdown et al. (2015) find that distractions during driving are becoming a systemic problem, since the cognitive resources of drivers are no longer only affected by discrete devices with defined distraction pathways, but are increasingly challenged by multiple devices and multiple means of distraction. Researchers are aware of the importance of a systematic approach; nevertheless, some distracting elements can only be addressed individually.

As mentioned before, plenty of elements are a distraction to the driver. Among visual distractions, which means that the driver has his eyes off the road, one important element is so-called salient objects, such as roadside billboards and advertisements, which attract the driver's attention (Chan & Singhal, 2013; Megías et al., 2011). These salient objects are becoming prevailing elements of the roadside, even though there are conflicting opinions on the amount (or percentage) of information that the driver gathers with their vision. Lansdown (1997) notes that when driving, drivers acquire approximately 90% of all driving related information using their vision, while Sivak (1996) warns that claims about the precise percentage of visual information used is premature. Nonetheless, vision and perception of visual input undoubtedly play a crucial part in the driving process. Due to their limited capacity of receiving information (Sperling, 1960; Wickens, 1992), drivers can experience problems in their short-term perception (or non-perception) of important traffic signalling.

The perception of roadside objects is comprised of three parts: perceptual processes, termed parsing, and the utilization stage (Anderson, 1990). If the message on the object is phrased as an assertion, the drivers' reaction will most likely be simply storing the meaning in their memory; if it is phrased as an instruction, they may follow that instruction (Jamson, Tate, & Jamson, 2005). The driver will most likely detect roadside elements if they are placed in their focus of expansion, meaning in the area directly in front of the vehicle on the road. If elements are placed outside of this area, visual fixations most often happen in the horizontal search window, to the left or right area of the expansion of focus (Crundall, Van Loon, & Underwood, 2006). If traffic signalization gives too much information at once, the driver will not detect all of it (Liu, 2005). This is also true for other relevant objects; because of this, Liu (2005) finds that consideration should be made to keep the given information on a single object to a minimum to avoid pressuring the driver and to keep the needed time for detecting information to a minimum, which contributes to driving safety.

Recently, much research has been conducted regarding the effects field of traffic signage on the driver, which included the aspects related to recognition, comprehension, distraction, response, and recollection (Al-Madani, 2000; Bener et al., 2006; Sun et al., 2011; Wang et al., 2010; etc.). Kaber et al. (2015) find that the types of signs also influence driver perception: signs with logos attract more attention and take slightly longer to process than guide signs, but this does not correlate to the operations of vehicle control, since driving operations are worse in the presence of guide signs in comparison to logo signs and even worse in an environment with no signs. Sun et al. (2011) find that there is a strong correlation between different indicators of driving behaviour (e.g. cognition time, acceleration changes, track offset distance, etc.) and the recognition process of traffic signs. As the information content on traffic signs increases, elements of recognition such as the duration of fixation, acceleration and offset distance accordingly also show an average increase, meaning that the more information a traffic sign includes, the higher the risk it presents to driving operations. The speed of driving has a significant effect on fixation time, acceleration, and track offset. Taking into consideration the fact that the perception of information is limited, Jamson et al. (2005) find that participants of their research remember only three to six elements from their environment at a time, and concluded that it is important that drivers only detect traffic signs and their perception not be disturbed by various commercial elements located in the direct traffic environment. Seven should be the upper limit of information items in a separate traffic sign (Jamson et al., 2005).

Various commercials or advertising materials, which present an ever-present external distraction during driving (Brumec, Herman, Hrabar Verzolak, & Polič, 2010), tend to attract the driver's attention and even affect their emotions and consequently their driving performance (Di Stasi et al., 2010; Pêcher, Lemercier, & Cellier, 2009). As Bendak and Al-Salem (2010) show, advertisements and billboards can affect drivers by confusing or distracting them during driving, for example by appearing to move, diverting the driver's eyes from the road, reducing visibility, etc. Various research has been performed into the effects of roadside advertising on driver behaviour (Bendak & Al-Salem, 2010; Crundall et al., 2006; Megías et al., 2011; Smiley, Smahel, & Eizenman, 2004; Wallace, 2003; Young et al., 2009). Chan and Singhal (2015) note that driver attention can be changed with roadside advertising with a negative or positive emotional content, meaning that these advertisements can cause poorer performance and distraction of the driver.

Research in the field of driver distraction connected to advertising is often performed using simulations, which do not necessarily reflect the real environment. Crundall et al. (2006) find that volunteers who watched a video of driving spent much time observing roadside advertisements. Lee, Olsen, and DeHart (2003) gathered information on driver performance when driving past billboards and find that they do not have any effect on driver performance, but this research was flawed in the sense that the drivers knew the environment in which the driving took place. Since this research was based on