Transportation Research Part F 23 (2014) 147–155

Contents lists available at ScienceDirect

Transportation Research Part F

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

Looking behavior for vertical road signs

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ARTICLE INFO

Article history:
Received 13 September 2013
Received in revised form 13 January 2014
Accepted 13 January 2014

Keywords:
Road signs
Visual fixations
Eye movements
Eye mobile tracking glasses

ABSTRACT

Visual fixations at vertical road signs and their recall was tested in 22 participants who drove a route of 8.34 km. Gaze was assessed by mobile eye tracking glasses. Recall was assessed at the end of the route by asking each participant to write in a route map all vertical sign that were remembered. The route was the same for all participants and included a total of 75 road signs. The results shown that only 25.06% of vertical signs were looked, and only 6.66% were recalled by the driver at the end of the route. The results are explained in terms of inattentional blindness, automaticity in driving behavior, and the angular offset of the vertical signs to the driver sight line.

1. Introduction

1.1. Vertical road signs

Traffic safety depends upon the integrated and complex relationship between various components: driver psychology, traffic, vehicle, environment and road infrastructure (e.g. Bucchi, Sangiorgi, & Vignali, 2012; Dondi, Simone, Lantieri, & Vignali, 2011). According to statistics, the aspect that seems to be the most important, as it is responsible for most accidents, is the behavioral component, and therefore the psychology of the driver of the vehicle (Petridou & Moustaki, 2000; Treat et al., 1977; Van Elslande, Naing, & Engel, 2008).

When considering the interaction between driver and road infrastructure, traffic signs play a significant role. Signs are used to control and regulate traffic and to promote road safety since they anticipate potential dangers, prescribe a correct behavior, and disambiguate potential conflicts in priority and intersection interpretation. By preparing the driver for a subsequent behavior necessitated by the road layout ahead the road signs facilitate the reaction required for the appropriate action (priming effect) (Charlton, 2006; Crundall & Underwood, 2001; Koyunku & Amado, 2008). This prior knowledge provided by traffic signs is indispensable for safer driving.

The Vienna Convention on Road Signs and Signals (United Nations Economic & Social Council, 1968), which came into force in 1978 and, as at 30 June 2004, has been undersigned by 64 countries, sets out standardized rules on the shape, background color, border color, size and symbols of all traffic signs. Article 2 of the Convention classes all road signs into seven categories: (a) danger warning signs; (b) priority signs; (c) prohibitory or restrictive signs; (d) mandatory signs; (f) information, facilities, or service signs; (g) direction, position, or indication signs; and (h) additional panels.

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1369-8478/$ - see front matter
http://dx.doi.org/10.1016/j.trf.2014.01.003

Compared to other road signs, vertical ones have the advantage of being elevated above the carriageway and therefore should be more visible. The use of contrasting colors and reflective treatments means that they are more conspicuous than road surface markings. They are, however, positioned at an angle facing slightly away from the carriageway and so the driver, who will usually look and focus ahead, must make a lateral saccadic movement to look at a vertical sign.

In this study, we wanted to verify to what extent drivers look at vertical signs under real driving conditions. It is very important to have exact statistics on driver's looking behavior with respect to vertical signs in order to test how important vertical signs are in influencing driving behavior. In addition, this study can be useful for testing whether the visual properties of the signs (shape, color, size, inscriptions) are effectively perceived or ignored by drivers.

Vertical signs are usually set between 0.3 m and 1.0 m from the edge of the carriageway. This clearance distance should be added to the distance between the side of the carriageway and the driver, so an average lateral distance between driver and sign is 2.0–2.5 m.

As well as the horizontal eccentricity of traffic signs in relation to the driver's line of sight, the vertical eccentricity should also be considered. The lower edge of the sign is usually placed between 0.6 m and 2.2 m above the highest point of the carriageway alongside it. In built-up areas, the height is higher in order to allow sufficient clearance for pedestrians (between 2.2 and 4.5 m). The eyes of a driver in a standard car are lower than the vertical sign. This implies that the driver will have to make a left-up eye movement in order to look at the sign.

The factors that determine the distance at which a sign should be legible at a given travel speed are: (a) the lateral clearance between the sign and the edge of carriageway and (b) the time needed to read and understand the message. Drivers should not have to move their eyes more than ten degrees away from the road ahead (Department for Transport, UK Government, 1982). Therefore, the meaning of a sign must be fully processed before drivers reach the point where their observation angle exceeds ten degrees. The faster their approach speed, the further away they must start looking at the sign.

The greater the number of signs that drivers are exposed to at one time, the greater the difficulty they have in assimilating the information, and the problem in dealing with information overload increases with age. This means that, in general, no more than two signs are placed on any one post. This includes the supplementary plate giving further information that is frequently placed below the main sign.

There are examples of roadways in urban settings with dozens of traffic signs, not to speak of all the additional sources of information and various distractions placed within a few minutes of driving time. When drivers are faced with more information than they can process, they may decelerate severely, drive too slowly, make late or erratic manoeuvres, go the wrong way, ignore critical information, fail to consider other traffic, or take their eyes off the road for too long (Xu, Guan, & Yan, 2011).

In addition, when vertical signs posts are set too close together, this can be disturbing for people who are particularly photosensitive, because the signs generate cyclical repetitions of light flashes (the flickering effect) (Dondi, Vignali, Lantieri, & Manganelli, 2012; Harding & Jeavons, 1994).

1.2. Attention and remembering

Paying attention to and remembering traffic signs were first studied by Johansson and Backlund (1970). Over 5000 drivers were stopped soon after they passed a traffic sign on a Swedish highway. Six signs were tested at the same location. Drivers were asked to identify the last traffic sign they had passed (roadblock paradigm), with 76% of the drivers correctly remembering speed limit signs, while between 26% and 66% of them remembered the warning signs.

In a similar study (Shinar & Drory, 1983), drivers were stopped at an Israeli army checkpoint which was 90 km from the nearest town. Drivers were requested to recall all the warning signs along the road. Correct driver recall was only 4.5% during the day and 16.5% during the night. These results confirmed those reached by Johansson and Backlund (1970), revealing the difficulty of remembering warning signs.

Another confirmation came from the research by Milosevic and Gajic (1986) who reported levels of sign recall of 2–20% for single signs and 34% for serially repeated signs. Cole and Hughes (1984) and Hughes and Cole (1984, 1986) have studied what drivers verbally reported as attracting their attention as they drove and found that the conspicuity of traffic signs and signals was generally quite low, on the basis of only 15–20% of driver reports, and as few as 10% of the traffic signs present were reported (Cole & Hughes, 1984; Hughes & Cole, 1986).

In addressing the question of seeing vertical signs, we should also consider that the angular diameter of foveal vision in humans is only 0.3–2°. Away from the fovea, relative acuity and resolution falls rapidly to a fifth of its maximum value at an eccentricity of 10° (Land & Tatler, 2009), and to a tenth at an eccentricity of 20°. Peripheral vision is rather poor in pattern recognition and color vision while it is rather efficient in motion detection (Strasburger, Rentschler, & Juttner, 2011). Zwahlen (1989) has also shown that peripheral visual detection distances decrease considerably as the peripheral visual angle away from the fovea, or line of sight, increases. A 10° peripheral visual detection angle resulted in an average visual detection distance approximately one-half of the average foveal detection distance. Dewar and Olson (2007) have reported that peripheral vision could play a role in the detection of traffic signs.

Traffic sign size is computed considering the maximum distance at which they have to be identified (this distance varies according to the road classification and average speed) considering foveal vision only. The size is not computed considering the azimuthal eccentricity between the sign and the driver's sight line.