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The failure to respond to changes in the road environment: Does road familiarity play a role?

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ABSTRACT

Road signs do not necessarily lead to the right response. Especially when signs are changed, drivers may not always detect new signs and may therefore fail to respond correctly to the situation indicated. The present driving simulator study investigated whether road familiarity (increased exposure to the same road) influenced failure to respond to a change in road signs. In order to study the failure to respond, participants were presented with a change in the road lay-out (as indicated by a road sign) in the last of a series of simulated drives. The change introduced was the conversion of a normal road into a No-Entry road. Results show that several participants failed to respond to this change. However, the failure to respond was not simply the result of familiarity with the road or prior exposure to precisely the same road, but seemed to be influenced by expectations induced by the road design. Additional safety measures such as the placement of additional road signs reduced the failure to respond. An auditory in-vehicle message gave the best results. Interestingly, both in the case of additional signs and of the in-vehicle message, a general warning was sufficient, without the need to specify the precise traffic situation.

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1. Introduction

Traffic accidents are caused by many different factors. One of these is a driver's failure to respond to information that is clearly visible and highly relevant to the driving task. When drivers take their eyes off the road, they will be unable to respond to traffic information. It has been found however that even when drivers are observing the road scene, they may still fail to select or respond to information that is relevant to their driving task even when that information is clearly visible (e.g. Charlton & Starkey, 2011; Harms & Brookhuis, 2016; Martens, 2011; Martens & Fox, 2007).

As Theeuwes (2010) describes, there has been decades of debate regarding the extent to which selection is controlled in a top-down way or in a bottom-up way (for reviews e.g. Burnham, 2007; Corbetta & Schulman, 2002; Theeuwes & Belopolsky, 2010). Top-down visual selection implies that selection is an active process completely under control of the intentions of the observer. Bottom-up selection is determined by the feature properties present in the environment in a passive automatic way.

Top-down visual selection is expected to play an important role in determining what information drivers pick up from the scene they are viewing. This means that people tend to notice elements of a scene that share some features with the specific object they are looking for (see e.g. Findlay, 1997; Treisman & Gelade, 1980; Wolfe, Cave, & Frantzel, 1989). Top-down selection also causes people who are looking for a particular object in a scene to start their search at the point where this object is

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most likely to be found. Searches for an object at an unpredictable location is likely to take much longer (Meyers & Rhoades, 1978; Theeuwes, 1991). Studies of expert performance clearly show the importance of top-down selection. Experts tend to focus their attention on domain-specific stimuli, whereas non-experts may also pay attention to other stimuli (Chase & Simon, 1973a, 1973b; De Groot, 1978; Groff & Chaparro, 2003; Pearson & Schaefer, 2005; Reingold, Charness, Pomplun, & Stampe, 2001; Werner & Thies, 2000). These results suggest that intentions, goals and expectations guide selection and hence perception. Such top-down selection, governed by intentions, goals and expectations, may however also introduce fallacies. Road users who are familiar with a road tend to develop expectations about the presence of objects on the road and how to respond to traffic situations. The essence of the fallacy is that drivers may respond to the expected situation even if the actual situation is different.

Although the effects of road familiarity on driver response have not been investigated often, some studies have shown that it is possible to study this effect in a driving simulator. In their simulator study, Charlton and Starkey found a decrease in the variability of certain behavioural measures with increased road familiarity (Charlton & Starkey, 2011; 2013). Specific elements of the road picture were detected most accurately in the first run of each session, while drivers' attention seemed to drop during the rest of the experiment. However, extended practice led to an improvement in detection performance: drivers apparently learned to proceduralise the detection task. In their 2013 study, Charlton and Starkey found that familiarity with visual features of the road was directly linked with drivers' feeling of driving without awareness. They concluded that it is not familiarity with the road scene in itself but rather driving without due attention that may cause detection failures. These authors found that when visual features were changed, the ratings for driving difficulty went back to the original level obtained during the first test drive. Changes, such as the addition of a new warning sign, were detected less reliably when drivers were more familiar with the road. Martens (Martens, 2004, 2011; Martens & Fox, 2007) also found road familiarity to have a strong effect on change detection. She concluded that expectations and road familiarity change the way drivers scan the environment and what they respond to. Martens and Fox (2007) found that the people spent less time looking at particular objects along the road when they had driven over that road several times. Using a driving simulator, these authors got participants to drive the same road several times over different days, thus increasing their familiarity with the road. The road lay-out was changed on the last day, by introducing new road markings and traffic signs at a particular junction so that drivers who had previously had priority over oncoming traffic now had to give way to traffic coming from the right hand side. It was found that people who drove the same section of road several times had more explicit expectations about what they would see on traffic signs than people who had driven over the same road only once. Apart from reducing glance duration, familiarity with the road was also reflected in an increase in average speed and more frequent failure to perceive changes. Measurements showed that drivers spent just as long looking at the new traffic sign as at the old one. This suggests that even though drivers did fixate on the information the traffic sign provided, they did not process this information enough to elicit the correct response. These results fit in with the idea that strong top-down information processing is operative here: increased exposure to the same road builds up such strong expectations that new information does not elicit the appropriate response since it is not in line with expectations. This is in agreement with the findings of Yanko and Spalek (2013), who state that drivers who are familiar with a road perform worse when faced with a hazard than drivers who are unfamiliar with the road.

Taken together, these results seem to indicate that increasing familiarity with the road leads to changes in perception and attention. It may then be asked whether the same effects would be produced if the road lay-out were changed but general traffic rules remained similar. The two main questions addressed in the present driving simulator study were therefore: (1) Do expectations that drivers have built up over time after simulated drives with a specific road lay-out lead to failure to respond to new situations only when the road lay-out remains unchanged, or would similar effects be produced when the road looks different but the traffic rules and situations remain the same? and (2) Can additional measures counteract the effect of these expectations so as to improve driver response?

2. Method

The primary objective of this study was to investigate the effect of road familiarity on the failure to respond to changes in the road environment. In line with this, the main research question was: Do drivers fail to respond to traffic cues only if they drive precisely the same route a number of times (reflecting the situation found in daily commuting), or can road familiarity also be gained by multiple drives over similar but varied routes? The second research question concerned the possibility of reducing the failure to respond to traffic cues with the aid of countermeasures such as road signs or in-vehicle messages. The study was approved by the TNO Human Factors ethical committee.

2.1. Participants

Eighty participants were initially selected for this study. The intention was that 10 participants should perform simulated drives under each of the 8 conditions described below. However, two participants had to drop out due to persistent simulator sickness, leaving a total study population of 78. All participants had driven more than 5000 kilometres a year, and had had their driver's license for at least 5 years. Both men and women participated and gender, age (between 23 and 60 years of age)

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