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The development of hazard perception: Dissociation of visual orientation and hazard processing

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A B S T R A C T

Eye movements are a key behavior for visual information processing in traffic situations and for vehicle control. Previous research showed that effective ways of eye guidance are related to better hazard perception skills. Furthermore, hazard perception is reported to be faster for experienced drivers as compared to novice drivers. However, little is known whether this difference can be attributed to the development of visual orientation, or hazard processing. In the present study, we compared eye movements of 20 inexperienced and 20 experienced drivers in a hazard perception task. We separately measured (a) the interval between the onset of a static hazard scene and the first fixation on a potential hazard, and (b) the interval between the first fixation on a potential hazard and the final response. While overall RT was faster for experienced compared to inexperienced drivers, the scanning patterns revealed that this difference was due to faster processing after the initial fixation on the hazard, whereas scene scanning times until the initial fixation on the hazard did not differ between groups.

1. Introduction

Eye movements are indicators for the selection of to-be-processed objects and thus an essential prerequisite for visual information processing. Effective ways of eye guidance are crucial for driving a vehicle and allow to detect and process potentially dangerous objects to avoid accidents. Especially young drivers are reported to exhibit a significant risk of crash involvement (Gregersen & Bjurulf, 1996). Furthermore, studies concerning the causes of accidents revealed that insufficient visual orientation is a major factor in the prediction of accidents (Dingus et al., 2006; Horswill & McKenna, 2004; Pelz & Krupat, 1974). For example, Borowsky, Shinar, and Oron-Gilad (2007) found that novice drivers were the least sensitive in responding to unplanned hazards as compared to two other groups of experienced drivers. Taken together, these pieces of evidence suggest that the mechanisms of visual information processing in hazard perception especially in novice drivers require closer attention.

Previous research revealed many details about differences in visual orientation between novice and expert drivers. In their seminal study, Mourant and Rockwell (1972) analyzed visual search strategies during driving on freeway and neighborhood routes. They observed that novices concentrated their search on a smaller area than experts and tended to fixate closer to the vehicle. Similar to these findings, Crundall and Underwood (1998) also reported significant differences between novices and experts while driving on dual carriageways, namely that experienced drivers showed a higher variance of horizontal gaze positions compared to novices. However, in easier traffic situations experts adjusted their scanning patterns accordingly, whereas novices exhibited rather inflexible visual routines, regardless of situational demands (see also

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Borowsky et al., 2007; Crundall, Chapman, Phelps, & Underwood, 2003; Crundall, Underwood, & Chapman, 1999). Further studies confirmed this tendency of novices towards stereotypical scanning patterns during driving (e.g., Underwood et al., 2003). A recent study by Falkmer and Gregersen (2005) replicated most of the findings reported above, additionally showing that inexperienced drivers fixate more often on in-vehicle objects and relevant traffic cues compared to experts. Finally, Summala, Nieminen, and Punto (1996) demonstrated that only experienced drivers were able to use ambient visual resources in addition to focal visual processing (see Leibowitz & Post, 1982; Previc, 1998, for this distinction of separate visual processing channels) to maintain vehicle control, although subsequent work revealed that ambient vision did not support hazard detection (Summala, Lamble, & Laakso, 1998). In sum, these studies indicate that experience goes hand in hand with a development of visual strategies that can also adapt to specific demands of the traffic situation.

Apart from such rather general differences in visual orientation between novices and experts, some studies explicitly focused on the role of experience in hazard perception (e.g., Underwood, Crundall, & Chapman, 2002b). For example, inexperienced drivers exhibited longer fixation durations on potentially dangerous objects (Chapman & Underwood, 1998; Falkmer & Gregersen, 2005). Some studies reported direct evidence for slower hazard detection in inexperienced drivers (Grayson & Sexton, 2002; Hull & Christie, 1993), whereas others only reported non-significant trends (Sagberg & Bjornskau, 2006).

However, little is known about what aspects of hazard perception performance are developed from novice to expert drivers. In the studies reported above, the main parameter of interest was the time between the onset of a scene and a response, such as a decision whether the situation is dangerous or not (Hull & Christie, 1993). However, at least two different ways of gaining expertise are imaginable in the context of hazard perception: (1) a faster visual search for potentially dangerous objects as a result of "knowing where to look" (early processing skills related to visual orientation), or (2) a faster decision whether a spotted object is dangerous or not (late processing skills related to hazard processing). The studies reported above did not report data on such distinct sub-processes of hazard perception.

2. Objectives

The aim of the present study was to separately assess the time until the first fixation of a potentially dangerous object and the subsequent time until the final response to determine which of these distinct measures develops from inexperienced to experienced drivers, which is only possible by combining standard response time and eye movement analyses. To this end, we presented static traffic scenes with either low, medium, or high braking affordance (see Gibson, 1977) to inexperienced and experienced drivers while participants' eye movements were monitored. Their task was to respond with a button press whenever they would initiate a braking response. For a subsequent analysis, we defined hazard regions and separately calculated the time until a hazardous region was fixated for the first time and the time from this first fixation until a braking response was initiated.

3. Method

3.1. Participants

Twenty experienced and 20 inexperienced drivers, aged from 16 to 28 years, took part in this study. Experienced drivers were mainly students from RWTH Aachen University. Inexperienced drivers were recruited from local schools. The experienced drivers were outside their German probationary period, resulting in a driving experience from 24 months to 8 years ($M = 5$ years), whereas the inexperienced drivers were subjects within their probationary period, resulting in a driving experience from 0 months (subjects that were still at driving school) to 23 months ($M = 9$ months). The mean lifetime estimate of driving experience (based on questionnaire data) amounted to 22,942 km ($SE = 6909$) for the experienced drivers as opposed to 6536 km ($SE = 3028$) for the inexperienced drivers, $t(38) = 2.175$, $p < .05$. The mean age was 24 years ($sd = 2$ years) for the experienced drivers and 18 years ($sd = 1$ year) for the inexperienced drivers. The experienced drivers consisted of nine female and eleven male participants, whereas the inexperienced drivers consisted of seven female and 13 male participants. All had normal or corrected-to-normal vision.

3.2. Materials and apparatus

The pictures of traffic situations used in the current experiment were taken from a previous reaction time study (Biermann et al., 2008). They consisted of 90 scenes, which show traffic situations from the drivers' perspective. The pictures stem from real traffic environments and selectively contain situations of variable braking affordance, such as road works, flashed braking lights of a car ahead, pedestrians, or children playing. Three experts (driving instructors) divided the pictures into three equally distributed categories of low, medium, and high braking affordance (see Fig. 1).

The assignment of the scenes to the three categories was validated in a previous study, where RTs for braking responses were measured in 1669 subjects (Biermann et al., 2008). In this study, the mean RTs for the scenes of medium braking affordance amounted to 1192 ms, as compared to 885 ms for the scenes of high braking affordance, $t(1668) = 47.6$, $p < .001$. The scenes of low braking affordance only received few braking responses ($M = 11\%$). We reasoned that these behavioral differences across categories supported the notion of various degrees of braking affordance.

Fig. 1. Examples for traffic scenes used in the present study. From left to right, these represent an example of a low, medium, and high braking affordance traffic scene.

In the pictures depicting medium and high affordance scenes, rectangular regions were drawn around the potential hazard (see Fig. 2). It was ensured that the overall mean size of these hazard regions as well as their spatial distance from the preceding fixation cross (see below) did not differ between both categories.

Prior to the main experiment, we conducted a pretest to ensure that inexperienced and experienced drivers did not differ regarding their visual scanning routines on a general level. For this means, we selected 40 scenes with landscapes without any relation to traffic and 20 further safe traffic scenes that were not used in the main experiment.

Eye movements were recorded using a head mounted EyeLink I system with a temporal resolution of 250 Hz and a spatial resolution of few minutes or arc.

3.3. Procedure

Subjects were seated at a distance of 70 cm in front of a 21″-monitor with a chinrest and a keyboard in front of them. The pretest contained landscape and safe traffic pictures that were shown for 2 s each in fixed randomized sequence. All pictures subtended a visual angle of $24.0^\circ \times 18.6^\circ$. The subjects' task was to explore the pictures and to answer an easy, not traffic-oriented question after every fifth picture concerning the presence or absence of particular objects in the previously viewed scenes. This task was supposed to induce a comparatively natural eye movement behavior and served as a control condition to ensure that inexperienced and experienced drivers did not differ with respect to general scene scanning patterns.

In the main experiment, 90 pictures from all three traffic scene types were presented in fixed randomized sequence. Each picture was shown for 2 s. Pictures were separated by a black screen for 1000 ms, followed by a white fixation cross in the upper left corner of the black screen to ensure that subjects did not fixate anywhere in the picture during onset. Subjects were instructed to respond as quickly as possible to those scenes which subjectively demanded a braking response or speed reduction by pushing the space button of the keyboard in front of them. A recalibration of the eye movement registration device was conducted after every five trials. In sum, the experiment lasted about 35 min.

3.4. Design

The percentage of braking responses was analyzed using a 2x3 mixed ANOVA with the independent variables (IV) expertise (inexperienced vs. experienced) and scene type (low, medium, and high braking affordance). We did not implement sig-

Fig. 2. Example of a scanning pattern of one participant. The scanning proceeded clockwise, with dots representing fixations and lines representing saccades. The rectangle in the middle, which was not visible for the subjects, represents the hazard region.

nal detection theory (SDT) for a further analysis of the responses, since an important prerequisite of SDT, namely physically defined signals for an unequivocal definition of hits and misses, is missing due to the strong subjective component of what is regarded as a potential danger, especially in the medium braking affordance category. Response times, other response related measures as well as the eye movement parameters were analyzed using a 2×2 mixed ANOVA with the IV expertise and scene type (medium dangerous vs. highly dangerous).

4. Results

Pretest: The pretest was implemented to rule out the possibility of different general picture scanning routines that were not related to hazard perception between groups. To do so, we separately analyzed the mean number of fixations, the mean saccade amplitude, and the mean fixation durations for landscape and safe traffic scenes. *T*-tests revealed that none of these parameters differed as a function of expertise, all $t < 1.02$. Furthermore, we analyzed fixation distributions by segmenting the area of the scenes into nine (3×3) rectangular areas of equal size. Afterwards, we computed the mean number of fixations for all segments that minimally received more than 5% of the fixations. However, in all these five segments the mean number of fixations did not differ as a function of expertise, neither for landscape nor for the safe traffic pictures, all $p > .17$. Subjects always responded correctly to the questions that referred to the content of the pictures.

Main experiment: Response-related data. In the main experiment, we discarded 12.75% of the trials from the experienced and 14.94% of the trials from the inexperienced drivers due to impaired eye movement data or response times that differed more than three standard deviations from the mean. This data loss was not systematically confounded with the experimental conditions.

The analysis of braking responses revealed a main effect of scene type, $F(1, 38) = 381.19$, $p < .001$. Post hoc *t*-tests revealed that significantly more braking responses were initiated for high braking affordance scenes ($M = 89.6\%$, $SE = 1.1$) as compared to medium braking affordance scenes ($M = 45.4\%$, $SE = 3.2$), $t(39) = 12.58$, $p < .001$, and for medium braking affordance scenes as compared to low braking affordance scenes ($M = 15.1\%$, $SE = 2.5$), $t(39) = 12.02$, $p < .001$. We did not find a main effect of expertise on the number of braking responses, $F(1, 38) < 1$, or an interaction of scene type and expertise, $F(1, 38) < 1$.

For the further analyses of response related parameters, we discarded all trials with low braking affordance scenes. From the remainder, we only selected trials where a braking response was initiated. The analysis of overall RTs, defined as the interval between picture onset and braking response, revealed a significant main effect of expertise, $F(1, 38) = 21.91$, $p < .001$, indicating that experienced drivers responded faster than inexperienced drivers (see Fig. 3). We also found an effect of scene type, $F(1, 38) = 125.91$, $p < .001$, indicating that high braking affordance scenes were responded to faster as compared to medium braking affordance scenes. There was no significant interaction of expertise and scene type, $F(1, 38) < 1$.

Time until first fixation vs. subsequent time until response: The analysis of time until first fixation, defined as the interval between scene onset and the first fixation on the hazard region, revealed no significant main effect of expertise, $F(1, 38) = 1.76$, $p = .19$. However, there was a significant effect of scene type, $F(1, 38) = 43.86$, $p < .001$, indicating faster hazard fixation for high braking affordance scenes as compared to medium braking affordance scenes. The interaction of expertise and scene type was not significant, $F(1, 38) < 1$.

The analysis of the subsequent time until response, defined as the interval between the first fixation on the hazard region and the braking response, however, did show a significant effect of expertise, $F(1, 38) = 11.43$, $p = .002$, indicating that the corresponding processes were finished faster for experienced as compared to inexperienced drivers. There was also an effect of scene type, $F(1, 38) = 11.29$, $p = .002$, indicating that hazards of high braking affordance were processed faster than those of medium braking affordance. The interaction of expertise and scene type was not significant, $F(1, 38) < 1$.

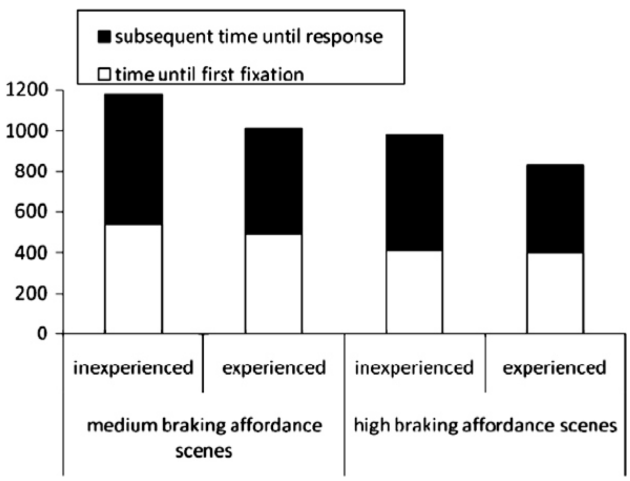

Fig. 3. Overall reaction time as a compound measure of time until first fixation (lower part of the bars) and the subsequent time until final response (upper part of the bars) across scene categories for inexperienced and experienced drivers.

Table 1
Eye movement parameters as a function of expertise and scene type (*SE* are given in parantheses).

		Number of fixations (N)	Fixation duration (ms)	Saccade amplitude (pixels)
Experienced drivers	Highly dangerous	2.93 (0.15)	297 (5.8)	144 (4.1)
	Medium dangerous	3.23 (0.16)	300 (5.4)	63 (1.7)
Inexperienced drivers	Highly dangerous	3.18 (0.15)	298 (5.8)	152 (4.1)
	Medium dangerous	3.30 (0.16)	297 (5.4)	69 (1.7)

Further eye movement analyses: Eye movement parameters during the whole inspection of the scenes were further analyzed (see Table 1). The analysis of the mean number of fixations per scenes showed that experienced drivers did not significantly differ from inexperienced drivers, $F(1, 38) < 1$, but that high braking affordance scenes were inspected with fewer fixations as compared to medium braking affordance scenes, $F(1, 38) = 13.73$, $p < .001$. The interaction of expertise and scene type was not significant, $F(1, 38) = 2.68$, $p = .11$.

The mean fixation duration, computed across all fixations on each scene, was neither significantly affected by expertise, nor by scene type, and the interaction of expertise and scene type was also not significant, all $F < 1$.

The mean saccade amplitude, computed across all fixations on each scene, was marginally affected by expertise, $F(1, 38) = 3.40$, $p = .073$, indicating a tendency for experienced drivers to scan with shorter mean saccade amplitudes. However, high braking affordance scenes were scanned with substantially longer saccade amplitudes as compared to medium braking affordance scenes, $F(1, 38) = 1171.50$, $p < .001$. The interaction of expertise and scene type was not significant, $F(1, 38) < 1$.

Gender effects: To further explore the data, we additionally conducted a gender analysis. We compared male and female participants regarding their overall response time, visual orientation time and hazard processing time across highly and medium dangerous scenes, but did not find any significant differences, all $t < 1.09$. However, a comparison of the number of braking responses revealed that for medium braking affordance scenes, female users more often responded with a braking response ($M = 49.7$, $sd = 15.3$) as compared to male participants ($M = 40.6\%$, $sd = 12.2$), $t(38) = 2.10$, $p = .042$, whereas we did not find significant effects for the high braking affordance scenes, $t(38) = 1.55$, $p = .13$, or the low braking affordance scenes, $t(38) < 1$.

Saliency analysis: Finally, we further analyzed the saliency of the hazard regions in the scenes of medium and high braking affordance. To do so, we used a software-based algorithm by Itti and Koch (2000) to compute whether the hazard regions contained salient elements. On the basis of the results of this analysis, we pooled all medium and high braking affordance scenes and divided these into two hazard categories of either low or high saliency. We subsequently added saliency (low vs. high) as an additional independent variable to the ANOVA. As a result, we found no main effect of saliency on overall RTs, $F(1, 38) = 1.86$, $p = .182$. Furthermore, saliency did not interact with either expertise, or scene type, all $F < 1$. A subsequent further analysis was only run for the high braking affordance scenes, since only these were about equally distributed across both saliency categories. The results did not reveal any significant effects of saliency on either time until first fixation, $F(1, 38) < 1$, or the subsequent time until response, $F(1, 38) = 1.23$, $p = .275$.

5. Discussion

The aim of the present study was to analyze the development of hazard perception performance from inexperienced to experienced drivers. To this end, we had subjects respond to static traffic scenes whenever the scene demanded a braking response or speed reduction. The pictures depicted traffic scenes of either low, medium, or high braking affordance. Most importantly, we additionally registered participants' eye movements throughout the experiment. This allowed to divide overall RT into two distinct sub-components, namely the time until first fixation, defined as the interval between scene onset and the first fixation on the hazard, and the subsequent time until the final response.

As a result, we did not find evidence for a change in the criterion to initiate a braking response between experienced and inexperienced drivers, since the relative number of braking responses did not differ as a function of expertise in any of the scene types. This indicates that the groups did not differ with respect to the classification of a situation as being hazardous.

However, overall hazard perception RTs were shorter for experienced compared to inexperienced drivers. This finding is in line with previous research that reported beneficial effects of expertise in hazard perception (Grayson & Sexton, 2002; Hull & Christie, 1993). The classification of the traffic scenes as being either of low, medium, or high braking affordance was validated by the significant differences in the overall amount of braking responses for the three categories. Furthermore, subjects were faster in responding to scenes of high braking affordance as compared to those of medium braking affordance, and this difference was also reflected in both time until first fixation and the subsequent time until final response. However, the underlying mechanisms of these effects of scene type must remain elusive on the basis of the present data, but this does not endanger the interpretation of any main effect of expertise.

Most importantly, the analysis of the effects of expertise on time until first fixation and the subsequent time until the final response revealed that only the latter significantly decreased as a function of expertise. This probably indicates that experienced drivers did not differ from inexperienced drivers with respect to the knowledge "where to look", but were faster in initiating a decision whether a fixated object represents a hazard or not, subsequently executing the corresponding braking response. This result is in line with previous research showing that inexperienced drivers exhibited longer fixation durations on potentially dangerous objects as compared to experts (Chapman & Underwood, 1998; Falkmer & Gregersen, 2005).

However, it should be noted that the separation of visual orientation processes and hazard processing based on the analysis of two different response systems (eye movements and manual responses) is to some extent oversimplified, and there is no certainty that time to first fixation only measures visual orienting and that the remaining time until the manual response only measures hazard processing. It is possible, for example, that recognition of the hazard occurs with the aid of peripheral vision (that is, before the hazard is fixated), and the ability of peripheral processing might additionally be mediated by expertise (see, e.g., Crundall et al., 1999; Miura, 1990; Unema & Rötting, 1990). If we assume that experienced drivers use peripheral vision more effectively, it is thus possible that hazard processing time is in fact comparable between groups, but the temporal onset of hazard processing occurs earlier in experienced drivers as compared to inexperienced drivers. This alternative explanation does not endanger the overall conclusion that experienced drivers are more efficient with respect to hazard processing, but the specific mechanisms involved (in terms of the role of peripheral vision) would be different. Furthermore, it is possible that visual orienting processes continue even after a hazard is fixated, or that visual orienting and hazard processing occur in parallel. However, these more fine-grained issues cannot be finally decided on the basis of the present data, and should be addressed explicitly in future studies.

One could argue that the choice of traffic scenes in the present study might only contain highly salient hazards, subsequently covering any effects of expertise on visual orientation processes. However, this objection is not plausible because of two reasons. First, the scenes of the present study were not artificially created with the aim to introduce salient hazards, but rather represent natural pictures of hazards in real life, since they were stills taken from videos that were shot during normal driving. Second, based on algorithms of Itti and Koch (2000) we explicitly categorized our set of pictures with respect to the saliency of the hazard regions. However, a post hoc comparison of hazards with high vs. low saliency did not reveal any significant differences. This renders it unlikely that an overrepresentation of highly salient hazards has covered effects on visual orientation processes. Based on the results from the pretest, we can also exclude the possibility that our two groups of subjects differed regarding their general scanning patterns for natural scenes.

Despite the lack of a group difference with respect to the time until the initial fixation of a hazard, it is still possible that during the individual development of visual information processing in traffic a knowledge of "where to look" is generated. However, this knowledge might already be established to a large extent before the acquisition of a driving license, probably due to traffic participation during childhood and adolescence.

Endsley (1995) claimed that novices have difficulties in integrating elements of the environment into a holistic perception of this environment, a skill which she termed situational awareness (see also Armsby, Boyle, & Wright, 1989; Brown & Groeger, 1988). More specifically, Benda and Hoyos (1983) reported that novice drivers tend to attend to rather unimportant details within the environment. However, whenever they do attend to a relevant object, it has been speculated whether they might at least in some cases "look but fail to see" (Brown, 2002). In the present study, the inexperienced drivers did not fail to classify an object as a hazard, but nevertheless seemed to need more time to process a potentially hazardous object. The results are therefore in line with the notion of a difficulty of inexperienced drivers in integrating newly fixated elements into an overall representation of a scene, which seems a prerequisite of judging its hazard potential. Recent research has pointed out that this difference in behavior between novices and experts cannot easily be compensated by specific training programs that instruct novices to simulate the behavior of experts (Dewhurst & Crundall, 2007).

A further (related) important implication of the present data is that mere fixation does not seem to warrant thorough cognitive processing of the fixated object. This observation places limits on the interpretation of studies that utilize gaze direction as a direct measure of visual attention and cognitive processing (e.g., Dingus et al., 2006).

A closer analysis of the eye movement data revealed that there were no pronounced group differences regarding the number of fixations on a scene or the mean fixation durations. However, there was a tendency of shorter mean saccade amplitudes for the experienced drivers, probably indicating that they tend to scan the pictures in a more thorough fashion as compared to inexperienced drivers. The substantially reduced saccade amplitudes for medium braking affordance scenes as compared to the high braking affordance scenes are likely due to comparatively short saccades during hazard processing, which took more time compared to hazard processing in scenes of high braking affordance.

A post hoc gender comparison revealed that male and female participants did not substantially differ with respect to temporal parameters, consequently ruling out the possibility that the response time effects are due to the slight imbalance of the gender distribution between groups. However, females more often initiated a braking response in scenes of medium braking affordance, that is, when the classification of a situation as being hazardous was to some extent ambiguous. This shows that females have a more liberal criterion in classifying a situation as being hazardous, probably representing a more careful behavior in traffic. This finding is in line with previous research on gender differences in traffic situations (e.g., Schade, 2001; Williams, 2003). However, this effect should not endanger the main finding of the present study, which refers to the differential effects of experience on visual orienting and hazard processing times.

One might argue that by using static scenes the results of the present study do not easily transfer to more realistic traffic environments. Some of the previous studies on hazard perception consequently involved real driving situations or, alternatively, video-based simulations (e.g., Underwood et al., 2003). However, in such realistic driving situations it is difficult to asses the amount of processing difficulty that solely stems from visuomotor processing, since vehicle control is always additionally involved and might itself influence performance (see Underwood et al., 2002, for a similar argument). Furthermore, in video scenes it should be more easy for subjects to prepare for dangerous objects, since these often appear gradually with relatively slow temporal dynamics. However, in normal traffic situations it is a common demand to rapidly process a completely new visual scene without any preparation, e.g. looking to the left and right prior to crossing a street. These demands can be approached in the laboratory by using static scenes, where the onset of a given situation is clearly defined and no preprocessing of the surroundings is possible. This methodology therefore stresses the demand of a rapid orientation in new situations, and should make any differences in the ability to suddenly orient in complex situations between inexperienced and experienced drivers more pronounced, although the sudden onset of pictures certainly lacks the context and preview information that is typically given in natural environments. Probably, the use of static scenes in the present study contributed to finding significant effects of expertise on hazard perception skills, whereas some previous studies using video-based material only reported non-significant trends (e.g., Sagberg & Bjornskau, 2006).

Nevertheless, it might be speculated to what extent the present findings might transfer to real traffic situations. Although the present effects in the millisecond range may appear small at first sight, drivers with a speed of 130 kp h will travel an additional 6 m in 170 ms. Furthermore, in the present study additional processing demands, e.g. handling controls, were avoided. In a realistic driving situation, one might therefore expect that such additional demands further increase the obtained differences between inexperienced and experienced drivers (Crundall & Underwood, 1998). Additionally, previous research indicated that the useful field of view, i.e. the region around a fixation where useful information can be extracted, might be limited in novice drivers, especially under high processing demands (e.g., Crundall et al., 1999; Miura, 1990; Unema & Rötting, 1990). Since the extraction of information from the parafovea should also play a role in the process of visual orientation, it is possible that visual orientation time might be affected in inexperienced drivers under high processing demands. However, further research is needed to further clarify this possibility.

In sum, the present study showed that hazard perception was faster in experienced drivers as compared to inexperienced drivers. This advantage in overall response time was probably mainly due a faster completion of late processes associated with hazard processing, and not due to early processes that are more strongly associated with visual orientation.

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