Does road familiarity change glances?
A comparison between watching a video and real driving
10.1 Introduction

When a road user drives along a road, different aspects of the environment demand and compete for attention. How does this process of allocating attention to different objects work and how do drivers select information? It is expected that attentional factors such as motivation, expectation, vigilance, mental effort and divided attention play a crucial role in visual selection performance. Hughes and Cole (1988) state that the driver’s information needs should have a significant effect on visual search strategy. When people are uncertain about their surrounding environment, for instance if they are driving in a new road environment, they will be more actively searching for information. Theeuwes (1989) states that top-down visual search only takes place when a driver is uncertain about the situation, and is actively searching for information in order to reduce this uncertainty. This implies that in a road environment that is highly predictable to the driver (for instance because he or she has driven the road numerous times), the driver may not actively search for relevant objects and may pay less attention to the driving task.

Martens and Fox (in press) addressed this issue in a simulated driving task. They showed that drivers spent less time glancing at traffic signs the more often they drove a particular road stretch. In addition, even though these drivers glanced at the traffic signs less often they knew what was displayed on these traffic signs, suggesting that driving the same road several times leads to stronger explicit expectations. One could argue that it is only logical that items that have been encountered before are glanced at for shorter periods of time. Studies have shown that viewers tend to cluster their fixations within informative regions of a scene (Antes, 1974; Buswell, 1935; Mackworth & Morandi, 1967; Yarbus, 1967). If one already knows what certain objects represent (because it was fixated before), it may be semantically less interesting. However, other studies found that viewers were no more likely to fixate the more informative target object than the less informative object early during scene viewing (Henderson, Weeks & Hollingworth, 1999; De Graef, Christiaens & d’Ydewalle, 1990), and Friedman (1979) found no effect of informativeness on the number of discrete looks to an object from a position beyond that object. This definition of ‘informativeness’ remains to be the problem in many studies, showing the relationship between informative scene regions and fixations (Mackworth & Morandi, 1967; Antes, 1974; Buswell, 1935; Yarbus, 1967). In reading, it has been found that unfamiliar words require longer fixations than common words [Rayner & Pollatsek, 1989]. The idea here is that unfamiliar words [as may be the case for unfamiliar objects] require more processing and therefore the measure of fixation duration may be considered to reflect object identification time [Henderson, Pollatsek & Rayner, 1987; Underwood & Everatt, 1992]. However, the direct transfer from this knowledge of reading or watching pictures to looking while driving a car or watching a video of the driving scene remains to be difficult.
Given the findings of Martens and Fox (in press), one can argue that people only need to passively update their existing mental model if they are familiar with the environment, which appears to require less attention than actively encoding the environment. These results are in correspondence with findings of Martens (2004). She found that in artificial experimental settings, participants spend more time glancing at objects they consider to be relevant (targets among distractors). In this sense, a traffic sign can be considered to be less relevant if the information on the sign is already known.

However, a problem with the notion of passively updating the mental model is that it may very well be that drivers do not notice changes to road environments if they are not actively scanning their surroundings. First studies in simulated task environments have shown that quite a large part of the participants do not notice information that is not in accordance with their expectations or when they do notice, their responses are delayed (Martens, 2004; Martens & Fox, in press). This negative side of getting familiar with a certain task environment might be the result of not spending enough time glancing at the objects in the task environment. But this decrease in glance duration to objects in the task environment once people get familiar with the environment has only been shown in computer simulated environments. It would be important to determine whether passively scanning the objects in the surrounding once people get familiar with the environment can also be found in the real world.

Many studies have shown that attention and eye movements are guided by a common selection process (Bichot, 2001). We attend to objects of interest while ignoring irrelevant ones. Mori and Abdel-Halim (1981) found that under free driving conditions (without a specific search instruction) only 11.2% of the traffic signs were fixated for a duration that was equally long compared to the condition in which participants were instructed to read all the signs. Zwahlen (1981, 1987, 1988) reported that driver’s eye scanning behaviour is not much different for warning signs, advisory speed signs, curve signs, stop ahead, or stop signs although these signs have different guidance or warning purposes. For stop signs, Zwahlen (1988) found that test drivers fixated the signs on average between 1.45 and 2.77 times, with an average duration of between 650 and 820 ms. Curve warning signs were fixated on average between 1.6 and 3.5 times, with an average fixation duration of 510 to 620 ms (Zwahlen, 1987). Luoma (1988) studied the interdependence between fixations of the eyes and conscious perceptions during driving. This study addressed the controversy whether looking at an object actually entails "perceiving" (remembering) that object. He found that traffic signs that appeared in isolation were almost always perceived foveally and signs that were fixated were also always perceived. Road advertisements were perceived rather seldom, although one could argue that they may have been perceived and forgotten immediately since they were not traffic
related. The glance duration for the traffic signs was between 410 and 644 ms on average. Luoma states that a relatively short glance may be an indication of adequate characteristics of traffic signs related to information ergonomics. On the other hand too short a glance did not lead to perception (127 ms for a pedestrian crossing sign and 283 ms for a pedestrian crossing ahead sign). This last result is again a reason to believe that too short glances at specific objects because drivers are familiar with the road does not lead to perception and therefore changing information on a sign to indicate a changed situation may lead to dramatic results if this change in information is not perceived.

The objective of the present study is to show that this observed decrease in glance duration over subsequent drives, which may result in worse performance when things in the environment change, is also found under real driving conditions. In line with the previous findings it is expected that the more often a driver encounters a specific road, the less time he/she will spend glancing at specific objects, such as traffic signs. Glance durations could be different in a real driving task since the simulated and lab tasks that Martens [Martens, 2004; Martens & Fox, in press] used were less varied than real driving conditions, not having all elements that occur in a real traffic environment. First, typically in real driving there are many more visual elements along a road (houses, trees, pedestrians, cyclists, other cars) than there were in the simulated tasks. Second in real driving there is more variation from one trial to the next (difference in opposing traffic, different weather conditions, different pedestrians etc.). Third, typically the drivers’ field of view is wider in real life than in a lab environment with a computer monitor. It might therefore be the case that the decrease in glance duration found in the simulated environment is primarily due to the absence of any change from run to run, and not per se applicable to real driving scenarios. Fourth, the luminance values of simulated traffic signs on a computer screen do not correspond to the luminance values of signs in the real world, and the resolution of the image projector in simulations is somewhat limited. This results in recognition distances in a simulated environment that are smaller than in practice (Godthelp, 1980; Alferdinck & Hoedemaeker, 2004). This limited resolution may also result in differences in behaviour between real driving and simulated driving, as were found in a study with participants approaching a still-standing vehicle at high speeds and braking at the last moment possible. Only at high speeds, participants used a higher safety margin in the simulator compared to real driving (Kaptein, van der Horst & Hoekstra, 1996). In the range of more high-end simulators, these differences will be less.

In addition to the goal of replicating previous findings concerning total glance duration in a real driving task, the study assesses whether there are differences in glance durations for specific objects between driving a particular road stretch
and watching this very same road stretch on video. The main difference between
driving and watching a particular road stretch is that actual driving is more risky
(things may happen that are not under control of the experimenter and situations
may be different between various participants). By comparing the glance durations
found in real driving with glance durations when watching a video (and pretending
to be driving), it can be determined whether using videos as stimulus material for
assessing glance durations and decreases in glance durations to specific objects would
be feasible for future studies. In the current experiment, it was deliberately chosen
to actively involve the viewers of the video by having them pretend to be driving. If
participants watch a video of the same road several times for several days, it may be
that boredom leads to daydreaming (probably to a less active eye scanning patterns
than people would have in real driving) or to attention being drawn to other objects
not relevant to the driving task. Although this is an interesting research question
in itself, the main goal of this experiment was to find evidence that assessing total
glance duration and frequencies when participants get familiar with a certain type
of road environment can be done with showing videos as well as in real driving
conditions. Since there was some doubt whether this would succeed in the condition
of passively watching a video (due to the familiarity aspect), it was decided to have
participants simulate they were driving. If this turns out to be a valuable tool for
assessing glance durations to specific objects, this will suggest that time-consuming
field experiments (you have to drive to a specific area) are not really necessary
anymore. In addition, it allows experimental control over adverse effects of weather
conditions (bright sunshine is not to be preferred in eye movement studies) and
variance between different conditions to which participants are exposed (it is hard
to make sure that all participants receive the same situations). An advantage of
showing a video while participants simulate to be driving compared to just showing
a video is that responses to certain situations can also be measured, such as letting
go of the gas pedal (or braking) before entering a curve or a braking response to an
unexpected event (braking lead vehicle, child crossing the street etc.). It also offers
the possibility to change things in the same road environment from one drive (video
scene) to the other (something which is almost impossible in real life) but still show
a very realistic image (compared to some simulations in which specific colours may
be far more conspicuous than they would be in real life). This offers some more
flexibility in the types of issues to be investigated compared to passively watching a
video. The driving behaviour itself is however not part of this study.

There are a few studies that compared driving in real traffic with watching the very
same road on video passively. However, these studies were not focusing on glance
duration, but rather on performance or obstacle conspicuity. Hughes and Cole (1986)
instructed drivers to verbally report all the objects that attracted their attention. Half
of the participants watched a 16mm colour movie made from the route and half of
the participants actually drove a vehicle in this environment. The verbally reported data indicated that in comparison to real driving a movie provided a reasonably adequate simulation. The problem with the study is that verbal reports may omit information that participants use to perform a task (Ericsson & Simon, 1980). There is even some evidence that in verbal reports, participants do not report all items they actually perceive, since the percentages for reported traffic-related items are quite low in several studies (a.o. Hughes & Cole, 1986; Renge, 1980). It might very well be that participants see more than they can verbalise, since verbalising takes more time than perceiving per se (Martens, 2000). MacDonald and Hoffman (1984) found that retrospective verbal reporting of road sign information in a laboratory experiment using movie satisfactorily replicated results obtained in a field trial. These studies suggest that the absence of the driving task did not have a substantial effect on reporting behaviour. Again, in these studies, glance durations to specific objects were not measured, so it remains unclear whether this comparison of results also holds for glance durations. Hughes and Cole (1988) investigated eye movement behaviour involving participants watching a video without any other task and with a compensatory tracking task. The tracking task was located near the focus of expansion and was intended to be a simulation of the kind of demand imposed by longitudinal vehicle control. In the free conditions participants were just asked to watch the film, in the memory condition participants were told that they would need to answer questions about the film afterwards. In the attention conspicuity condition, participants had to report all objects that attracted their attention and in the search conspicuity condition, participants had to report all road traffic control devices and experimental disc targets along the route. Watching the video resulted in a broader distribution of horizontal fixation locations compared to the conditions in which participants were also performing a tracking task. The left region (Australian study, so road signs were located on the left side) was progressively more fixated as the specificity of the instruction changed from free observation to search. Under completely non-directed observations (free) the left region lost its apparent importance so that sky, road and central regions assumed just as much importance in attracting fixation. Hughes and Cole state that a driver does not passively acquire information but instead makes some attempt to purposefully interrogate the visual environment based on his information requirements and previous knowledge about the location of specific objects in the road scene. Cohen (1981) found that eye movement behaviour differed between drivers viewing the road and observers looking at a photograph of the same scene. However, this study was done under static conditions and may therefore not be applicable to the current research question. Lee and Triggs (1976) found that the detection of peripheral lights from a vehicle was not affected by whether the observer was a driver or a passenger, assuming that the act of driving
makes insufficient demand to affect visual behaviour. However, in Lee and Triggs’ study, participants were under all conditions confronted with the ‘real life’ traffic scene, something which is not the case for a video experiment.

The current experiment was conducted to determine whether the decrease in glance duration, as found in simulated environments, often leading to inadequate responses to changes in the environment, is also found in real driving. Second, the experiment is conducted to determine whether having participants watch a video while simulating driving is a valuable tool for analysing glance duration and glance frequency to specific objects.

10.2 Method
10.2.1 Participants
A total of 28 paid participants took part in the experiment. Participants were randomly assigned to one of two experimental conditions; the field condition (real driving) or the video condition. The ages ranged from 21 to 46, with both male and female participants included. All participants considered themselves to be experienced car drivers (having their driver’s license over 3 years and driving regularly). All 28 participants reported to have adequate visual acuity. None of the participants wore glasses or hard lenses, because of possible interference with the eye movement measurements.

10.2.2 Apparatus
A pupil/cornea reflection eye tracking system (ISCAN) was used to measure the eye movements of the participants. This was done by illuminating the left eye with an infrared source. A camera obtained a clear image of the eye by using an infrared pass filter to identify the dark image area of the pupil. Another camera mounted slightly below the left eye recorded the participant’s field of view. If the system is adequately calibrated, the system has an accuracy of 1 degree of visual angle. The eye tracking system had to be calibrated to the participant’s eye by means of five different calibration points. For every individual participant, the calibration procedure was performed before the start of the drives every day. The eye’s pupil and corneal reflection positions were calculated with a sample frequency of 120 Hz. The camera that recorded the participant’s field of view was connected with a Panasonic VCR. The camera image with the glances included was recorded on VHS tapes for later analysis. The cameras and the infrared source were built into a specially designed cap (see Figure 10.1). During the experiment, participants could move their heads like they would normally do while driving.
In the video condition a video taped from the driver’s point of view was played back on a Panasonic VCR and projected on a video screen by means of a HITATCHI XGA beamer. The projection screen had a width of 3 meters and a height of 2.5 meters. Participants were seated approximately 2.5 meters from the projection screen. A Logitech force feedback steering wheel and pedals (braking pedal and gas pedal, automatic gear) were used as input devices for the video condition. Participants were asked to pretend they were the driver of that car and to copy the steering, gas and braking behaviour of the ‘virtual’ driver. The virtual speed of the participant, measured by the force on the gas pedal, was shown on a separate display on the table in front of them. The simulated sound from the engine (linked to the virtual revolution-counter) was generated on a Pentium II computer and was played back using computer speakers attached to a Creative SoundBlaster soundcard.

The car used for taping the video condition was a Chrysler Voyager. For the field experiment (real driving condition), participants drove a Dodge Ram Van with an automatic gear. Just like every drive for participants in the field condition would
vary, the videos were also recorded over different drives, which led to differences between every video, but not to differences between participants (whereas there was a difference from participant to participant in what they encountered in the real driving condition). In the field experiment, the driving speed between participants could vary (since they regulated their own speed) whereas this was not the case for the video condition.

10.2.3 Task
The route (in both the field condition and the video condition) took the participants along a two lane road that was partly a rural road and partly an urban area. The total length of the route was 18 kilometers. Participants in the field condition were required to drive from the starting point to an end point, make a U-turn and drive back to the starting point. This was done four times in a row on one day with an instructor in the car providing directional information. Participants were instructed to drive as they would in normal life and drove with an automatic gear. The video condition showed the same route from a driver’s point of view, with the route projected on a video screen. The videos only showed the route itself, so the U-turns were not included in the video. To make sure there was enough variety in the video condition from one day to the other (as there would be for the field condition), video recordings of the route were made on three different days. To make the task more realistic, participants were instructed to copy the behaviour (steering, braking, and gas) of the ‘virtual’ driver from the video as good as possible. They were told that their actions would be recorded and that their driving behaviour would be compared with that of the virtual driver as a performance indicator. This was done to keep the participants’ attention committed to the driving task.

10.2.4 Conditions
The experiment consisted of two conditions; the field condition in which participants drove the 18 km route in a car and the video condition in which participants watched the same route from the viewpoint of a driver.

10.2.5 Procedure
In both conditions participants began with reading instructions before the actual experiment began. Participants were also verbally instructed to drive as if this was their daily trip home from work and to obey the traffic rules as they normally would. After reading the instruction, the baseball cap with the eye movement equipment was put on their head, participants were seated behind the steering wheel and the eye movement apparatus was calibrated by means of 5 different calibration points. The participants were told not to touch the cap containing the eye movement apparatus after the calibration process.
In the video condition participants sat behind the steering wheel and had a clear view on the video screen. When the video started participants were asked to ‘begin driving’ and ‘keep driving’ until the video stopped. Just like in the field condition, the participants ‘drove’ the route four times on one day without a break. Before every drive, a number on the video screen would indicate the drive number for participants to understand they would now start a new drive. The experimenter left the participant alone in the video room and went to an adjacent room with a window allowing a view on the participant. The only information provided by the driving instructor was the direction.

In order to build up expectations, participants either watched the video or drove the route four times in a row on three successive days. The video sequence was presented to all participants in the same order. It was decided to use three days since Martens and Fox (2003) found that the decrease in glance durations over days stopped more or less after three days.

10.2.6 Statistical analysis
The dependent variables used in this experiment were the total glance durations of specific predefined targets and the total number of glances (glance frequency) to the predefined targets. These two measures have been used before (a.o. Zwahlen, Russ & Schnell, 2002; Zwahlen, 1995) for assessing the information acquisition processing of road signs during normal driving.

A power analysis was performed for both dependent measures. In case that statistics did not show any effect, the power analysis was consulted in order to check if the data had sufficient power to reveal potential effects. If this was not the case, this will be stated when describing the absence of any effect. The probability of a Type I error was maintained at 0.05 for all subsequent analyses. In order to compare the total glance durations and glance frequencies, analyses of variance were performed with the independent variables Condition (with 2 levels, field or video), Day (with 3 levels), Drive (with 4 levels) and Object (19 different objects). Altogether 19 objects were selected out of a total of 42 signs the participants encountered along the route. The objects were selected to come to a combination of varied objects (road signs, markings on the road, informative signs, signs with symbols and signs with text, etc). Some objects were presented more than once. This allowed us to look at the differences between these signs. The 19 different objects are described in Appendix 10.1. If there is a number between brackets, this means that this object was not stand-alone but was combined with other objects in lateral position (e.g. [2] means that this object was combined with one other sign).
We use the term total glance duration for the summation of the total time participants glanced at the object. A cross superimposed on the road scene indicated the actual glance direction. All drives with the glance direction superimposed were taped on video. The analysis of these data was done by slow-playing the video with a reduction factor of 5 (5 times slower than normal playing speed). Every time the cross (glance direction) was within a range of 0.5 cm around a traffic sign within the area between 250 and 0 meter in front of the traffic sign (at this distance the traffic signs were clearly visible) this was recorded to be glanced at. If a participant glanced outside this spatial window the next glance inside this spatial window was considered to be a new glance. Although the acquisition of glances was done manually, the criterion of 0.5 cm was marked on the screen and did therefore not leave room for any subjective interpretation. The relevant objects never obscured one another (which could have led to confusion which sign was glanced at). Since it was a dynamic scene, participants followed the object with their eyes as it ‘moved’ relative to the participant, which also facilitated the decision what object was being glanced at.

10.3 Results

10.3.1 Comparison glance durations and frequencies between video and real driving

In order to determine whether there was a difference in total glance duration to the pre-specified objects between the two conditions, glance durations between real driving and watching the video were compared. There was no significant main effect of Condition on glance durations.

For glance frequency, there was a difference between the two conditions [F(1,26) = 6.43; p<0.02] with some more glances at the objects in the video condition (average of 0.91 glances over all objects in the video condition and 1.04 glances in real driving).

10.3.2 Familiarity with the road environment

For total glance duration, there was a main effect for Day [F(2,52) = 47.23; p<0.0001], with a decrease in glance duration over days. This was also the case for glance frequency [F(2,52) = 11.80; p<0.0001]. Also a main effect was present of Drive on total glance duration [F(3,78) = 6.76; p<0.0004] with decreasing glance duration with an increasing number of drives. The effect of Drive on glance frequency [F(2,52) = 3.33; p<0.02] showed the same type of pattern. In general it can be claimed that the more often people encounter the same road environment, the less time they spend glancing at objects, by decreasing the number of glances and by decreasing the glance duration per glance. For total glance duration, there was an interaction between Day and Drive [F(6,156) = 2.31; p<0.037].
The decrease in glance duration was mainly present for the ‘priority road’ sign, the ‘warning horse back riders’ sign, the ‘curve to the right’ sign, one of the ‘speed limit 50’ signs, the ‘start urban area Soest’ sign and the speed camera. The decrease was absent in case of the ‘warning pedestrians’ signs, two of the other ‘speed limit 50’ signs and the ‘end speed limit 50’ sign.

In case of the normal driving task under real driving conditions, traffic signs were not selected by road users in about 20% of the cases during the first drive. After driving the same road several times, traffic signs were not selected in about 25 to 35% of all
cases. When this same road was presented on video, this percentage was about 45% of the cases for the first drive. After virtually driving the same road several times in video, this was between 40 and 50% of all cases.

### 10.3.3 Type of object

There was a main effect of Object for the total glance duration [F(18,468) = 25.19; p < 0.0001] and for glance frequency [F(18,468) = 30.26; p < 0.0001], with quite large differences per object. The type of effect was similar for total glance duration and glance frequency.

A post-hoc Comparison (Fisher Least Significant Difference [LSD]) showed which objects differed from one another. It was important to determine which objects...
received long glances and which objects received short glances. Some precaution is needed when explaining long or short glances purely to the objects themselves. There may always be an effect of other factors such as background or objects in the vicinity, something that was not specifically controlled for here. The most important conclusion is that over all drives and days and conditions, the objects that received the longest total glance durations were the ‘warning horse back riders’, ‘start urban area Soest’ and the speed camera. The ‘warning horse back riders’ sign also received the largest number of glances.

The shortest glances were found for ‘speed limit 50’ (object 7) and ‘end speed limit 50’ (object 11). These signs also received the lowest number of glances.
For total glance duration, there was an interaction between Object and Day \([F(36,936) = 1.61; p < 0.014]\), with the decrease over days being larger for some objects compared to the other. This effect is shown in Figure 10.3.

A post-hoc comparison (Fisher LSD) showed that even though glance duration decreases over days, the objects that received the longest glances on day 1 are also the objects that received the longest glances on day 2 and day 3. This is also the case for objects having the shortest glances. However, the group of objects that received the longest glances increased with the days, since the total glance duration over days decreased (the high peaks for some objects decreased). This was also the case for the shortest glance durations; all objects that received the shortest glances on day 1 also received the shortest glances on day 2 and 3.
There is a 2-way interaction between Object and Condition for the total glance duration \([F(18, 468) = 8.23; \ p<0.001]\), with the total glance duration differing per condition. This interaction is shown in Figure 10.4 for the total glance duration.

A Fisher LSD showed a difference for two ‘speed limit 50’ signs (object 8 and 9, \(p<0.01\) and \(p<0.02\) respectively, with longer glances for video), two ‘painted speed limit 50’ signs (object 13 and 14, \(p<0.02\) and \(p<0.0003\) respectively, with shorter glances for video), ‘warning speed camera’ (object 17, \(p<0.002\), shorter glances for video), ‘start urban area Soest’ (object 18, \(p<0.006\), longer glances for video), and ‘warning pedestrians’ (object 4, \(p<0.002\), longer glances for video). The 2-way interaction between Object and Condition was also present for glance frequency \([F(18, 468) = 9.68; \ p<0.0001]\) and is shown in Figure 10.5.

There was a 3-way interaction between Day, Drive and Object, both for total glance duration \([F(108, 2808) = 1.51; \ p<0.001]\) and for glance frequency \([F(108, 2808) = 1.31; \ p<0.02]\). Also, a 4-way interaction between Condition, Day, Drive and Object was found for total glance duration \([F(108, 2808) = 1.36, \ p<0.009]\) and for glance frequency \([F(108, 2808) = 1.29; \ p<0.03]\).

### 10.3.4 Comparison on the first drive

This study was mainly conducted to investigate whether the decrease in total glance duration to road signs with increased exposure to the same environment in a simulated environment was also present in real driving and in watching a video while simulating driving. However, from a methodological viewpoint it would be interesting to see if there are any differences between these two conditions in the first drive on the first day. It may very well be that if familiarity would not have played a role, looking into the data from just one drive (not being interested in a possible change in glance durations after numerous exposures), results are different.

When analysing the total glance duration data of the first drive that participants made, there was no main effect for Condition. There was a main effect of Object \([F(18, 468) = 9.57; \ p<0.0001]\) and an interaction between Condition and Object \([F(18, 469) = 3.64; \ p<0.0001]\). This interaction is shown in Figure 10.6.

Selecting the objects that received the longest glances in the video condition did not lead to the same results compared to selecting the objects that received the longest glances in the real driving condition. Although there was overlap (some objects scored longest glances in the video condition and in the real driving condition), this was not the exact same selection of objects. There were quite large individual differences.
For glance frequency, also no effect of Condition was found, an effect of Object \( F(18,468) = 12.20; p<0.0001 \) and an interaction between Condition and Object \( F(18,468) = 3.55; p<0.0001 \), basically showing similar results as total glance duration. The interaction between Condition and Object indicates that the effect of type of object on the total glance duration and glance frequency differs between the two conditions.

### 10.4 Discussion and conclusions

The results show that using the total glance duration and glance frequency in a video condition with simulated driving instead of during real driving needs some caution. When looking into the decrease of total glance duration over days, as was
found before in simulated task environments, this phenomenon was present for the real driving condition as well as for the video condition. However for day 3, the total glance durations for the video condition are a little longer than for the real driving condition (see Figure 10.2). This may be explained by the fact that in the video condition, there are limits to the resolution of the projection. Due to the limitations in resolution of the projection, a ‘floor’ effect could have caused this small effect. It could have been the case that the lowest possible identification times for the video condition may be higher than the lowest possible identification times for the real driving condition. Therefore, it may be harder to get an equal reduction in glance duration after a certain point (floor) due to the difficulty to identify the objects at an early stage. However, there might be other explanations; participants in the real driving condition may encode the glanced objects more deeply and thus may become familiar with them more quickly. Alternatively, participants in the real driving condition may have diverted their attention quickly from the objects of interest in order to deal with other more pressing demands in the real-world driving task. No interaction was found for glance frequency, indicating the pattern for day was the same for both conditions. However, this conclusion does not necessarily hold since the power of this effect was low. The decrease of total glance duration over days and drives was more the result of people glancing at an object shorter per glance and less glances than the mere result of people having a lower number of glances at the different objects over days and drives. Irrespective of the explanation, the results indicate that the decrease in glance durations for objects after numerous exposures to the same road is present in both the field condition and the video condition. However, caution is required when using the exact values of the decrease in glance durations after numerous days. Also, the number of glances at objects is generally a little higher for the video condition, probably explained by the fact that under real driving conditions participants have more objects to glance at (wider viewing angle) and the driving task may be more pressing than with simulated driving.

There is also a clear difference in total glance duration between the individual objects, with some objects receiving longer glances than others, with quite some individual differences. Most of the objects that received the longest total glance duration also received the largest number of glances and this also held for the shortest glance durations and the least number of glances. However, an interesting element is that in general the decrease of total glance duration over days was present for all objects, and that objects that received longest glances (compared to other objects) at day 1 still received longest glances (compared to other objects) on day 2 and even on day 3. This may lead to the conclusion that objects that do attract longer glances (relative to other objects and irrespective of the number of glances) remain to do so even after...
people have seen or have driven this road numerous times (even though the absolute total glance duration decreased). However, an object that receives long glance durations on one location does not necessarily do so on another location. Based on these results, it seems impossible to claim that certain signs always receive short (or rather long) glances. Also, the claim that glance durations to objects presented in combination with other objects suffer in comparison to objects presented alone does not hold. Differences in glance durations between similar objects cannot simply be explained. The results for glance frequency were not directly related to total glance duration, not leading to the same stable decrease with exposure.

When comparing the glance data of the objects for the first drive of the first day, there was no systematic difference between the video and the real driving condition. However, the interaction between condition and object shows that total glance durations and glance frequency to the individual objects differ between the two conditions. Using the total glance duration or glance frequency data to select the objects in the video condition that received the longest glance durations does not lead to the exact same results as are found in the real driving condition, although there is overlap in identified objects in those categories.

Over all objects, no difference could be identified in the interaction between day and drive between the two conditions, neither for the total glance durations nor for glance frequency. However, the interpretation of this result should be dealt with care, since power of this specific effect was low. Over all drives, there was no difference in the interaction between day and object between the two conditions (again neither for total glance duration nor for glance frequency) and over all days, there was no difference in the interaction between drive and object for either parameters.

The present study confirms in part of our previous simulator study (Martens & Fox, in press) showing that drivers spend less time glancing at specific objects the more they drive a specific road stretch, but this time the results were found in a real driving situation. Also in the video condition this decrease was found. The results are also in line with earlier studies showing a decrease in total glance durations after numerous exposures to the same task environment in non-driving situations (Martens, 2004). This suggests that the decrease in glance durations as found before in the simulated environment, leading to drivers only passively updating their mental model and leading to a higher chance of missing changed information is also present in real driving. This illustrates a possibly serious safety risk.
10.5 General discussion and practical implications

In general it can be stated that the use of video (with instructions to participants that they have to simulate they are driving) for analysing total glance duration and glance frequencies for road signs can indeed be feasible for a limited selection of purposes, but that great care is needed. One of the main outcomes of the current study is that the decrease of total glance duration with increased exposure that has been found in simulated environments was also found in real driving. A second important outcome is that this decrease has also been found in the video condition. This means that over all objects, the two methods lead to comparable results when investigating total glance duration to objects. For glance frequency, people have slightly more glances at an object when watching a video compared to real driving and the decrease with increased exposure is not as gradual as it is with total glance duration.

However, when making a distinction between different objects, e.g. when looking into the objects that received the longest or shortest glance durations, there are indeed some differences between the two conditions. This means that the video configuration is not useful for identifying objects that would receive longest and shortest glance durations under real driving conditions. Although there are objects that receive the longest glances in the video condition that also receive the longest glances in the real driving condition, there is no exclusive overlap. So despite the fact that some studies have found similar results when comparing verbal reports during driving with watching a video (MacDonald & Hoffman, 1984; Hughes & Cole, 1986), this does not simply correspond to total glance durations to objects along the road.

This study did not look into the difference in glance duration and glance frequency between watching a video and watching a video while participants pretend to be driving. The results from the current experiment show that the latter method should only be used for exploratory or pilot research, looking into glance durations to road objects. The video tool is suitable for looking into the effect of multiple exposures or familiarity with the road environment on total eye glance duration without being interested in exact glance durations to objects as they would be in real life.
Appendix 10.1
List of 19 objects.

1) Priority road

2) Pedestrians

3) Pedestrians (3)

4) Pedestrians (2)

5) Danger horseback riders (on supplemental sign)

6) Curve to the right (2)

7) Speed limit (3)

8) Speed limit

9) Speed limit (2)

10) Speed limit (2)

11) End speed limit

12) Speed limit (50) painted on road (3)

13) Speed limit (50) painted on road

14) Speed limit (50) painted on road (2)

15) Speed limit (50) painted on road (2)

16) Information sign restaurant

17) Warning sign speed camera

18) Start urban area "SOEST" (2)

19) Speed camera