Accident Analysis and Prevention xxx (2008) xxx–xxx

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios

Panos Konstantopoulos*, David Crundall

Department of Psychology, University of Nottingham, Nottingham, UK

ARTICLE INFO

Article history:
Received 4 March 2008
Received in revised form 27 May 2008
Accepted 4 August 2008

Keywords:
Driving instructors
Visual attention
Visual prioritisation
Novice drivers
Drivers' training

ABSTRACT

Previous research has noted that novice drivers are at greatest risk of an accident. One reason that has been reported for this is that they have not developed the optimum visual search strategies of their more experienced counterparts. One might expect that new drivers might be taught the appropriate visual skills while learning to drive, though this requires instructors to have introspection into their own visual skills before they can be passed on to the student. In addition novice drivers should be able to acquire the instructed skills. This study used an image-based questionnaire to assess driving instructors' and novice drivers' priority ratings for attending to different areas of the driving scene across nine scenarios. It was predicted that if instructors and novices have introspection into the relative importance of these different areas, there should be agreement across the sample of participants. Additionally it was considered important to assess which areas of the visual scene are important across all different scenarios and which areas change in priority with a change in scenario. Results showed that for both groups the opinions regarding visual field prioritisation were highly consistent when compared to chance. Despite the rating consistencies, group differences were found, across all scenarios with "Rear View Mirrors" being the visual field with the most frequent observed group differences. Certain categories ("Road Ahead" and "Mirrors") were highly ranked across all scenarios, while other categories were more scenario specific. We conclude that both groups have insight into some elements of visual search. However, in many occasions the prioritisation was different between driving instructors and novice drivers. It appears that during the learning process the novice drivers did not adopt the prioritisation strategies seen in driving instructors. This has important implications for the teaching of visual skills in driving.

1. Introduction

Newly qualified drivers are over-represented in the accident statistics (Underwood, 2007). It has been proposed (Clarke et al., 2005) that attitudes of young drivers can explain certain types of accidents. However, it is accepted that when social and attitudinal factors are accounted for, novice drivers (NDs) are still lacking in skills. It seems that the skills NDs are lacking are not related specifically to vehicle control. It was suggested (Deery, 1999) that NDs' accident involvement it is not due to the driving skills acquired but it is due to slow development of cognitive skills. It was also claimed that motor skills could be acquired with 15 h of practise (Hall and West, 1996). It seems that during the driving training "chain" driving skills are transferable in a satisfied manner. As an assumption based on the above it can be said that driving instructors (DIs) successfully succeed on the transferability of motor driving skills.

In contrast visual search skills might be a factor in the accident involvement of NDs. Research has suggested that NDs have not yet developed an adequate attentional model (Crundall and Underwood, 1998; Deery, 1999). It appears that NDs' visual search guidance is not as efficient as more experienced drivers. This inefficiency might result in a reduced awareness of potential hazards and important driving operations and may partly explain this high accident involvement of NDs. One of the fundamental functions of visual attention is to select areas of the scene to process, which in turn require prioritisation hierarchy. It has been suggested (Itti and Koch, 2000; Treue, 2001) that since the environment contains an enormous amount of information evolution has developed a step-by-step intake of this information by allocating the gaze and attention on particular parts of interest. In driving terms it could be said that since most traffic conditions contain a large amount of visual stimuli the driver has to be able to prioritise and deploy his cognitive resources with efficiency. Considering the fact that it is only over the last 100 years that we have began to move

* Corresponding author at: University Park, Room 302, Nottingham NG7 2RD, UK. Fax: +44 115 951 5324.
E-mail address: lpxpk@psychology.nottingham.ac.uk (P. Konstantopoulos).

0001-4575/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.aap.2008.08.009

through the environment at such speed prioritisation and selection has become probably the most important aspect of vision in driving.

An additional point of interest is how current driving training curricula assist the development of efficient visual search strategies of drivers. In regards to the curriculum used in the UK there are some references to visual search (Miller and Stacey, 2006). However, the strategies involved to make drivers more visual aware are somehow general. Phrases like “look well ahead”, “keep the eyes moving” and “get the big picture” (Miller and Stacey, 2006, p. 79) are used to encourage effective visual search. Despite any effect that those techniques might have it needs to be acknowledged that they are very general therefore might not be as effective as one might hope.

It seems that although there are positive developments at drivers’ training further improvements are essential. In an ideal driving training, DIs should be able to guide learner drivers and train their visual attention and eye movements. This requires a consensus among DIs about an optimum prioritisation hierarchy. Furthermore DIs should have introspection into prioritisation which will allow them to pass on those explicitly to learners. Regarding NDs it is important to investigate whether have adopted the visual priorities of the DIs as this would suggest that NDs have successfully learned this prioritisation either implicitly or explicitly.

Unfortunately no previous research has addressed this issue. Although previous questionnaire based studies (Ozkan et al., 2006) have explored drivers’ self-reported behaviours and attitudes towards driving or safety there has not been any attempt to measure introspection into visual field prioritisation. Though behavioural and eye movement driving research has demonstrated clear experiential differences, we do not know whether the underlying visual strategies are open to introspection.

There are some possible reasons why NDs have not as efficient visual search strategies as more experienced drivers. One possible explanation is that the cognitive demands of the driving situation are so high that they are not able to prioritise the appropriate visual field due to cognitive overload. However, this explanation is not so likely since previous research (Underwood et al., 2002) has shown that there are visual search differences between experienced and NDs even when watching low cognitive demand stimuli like driving videos. So an alternative suggestion regarding NDs reduced visual search effect might be the lack of visual priority specific knowledge. Since learners acquire knowledge from DIs then this might be a possible broken link in driving training. Do DIs know what to teach in relation to visual prioritisation? In order to answer that question we need to assess DIs’ knowledge by measuring their introspection. If ranking of priorities is consistent amongst DIs then we can conclude that there is a shared knowledge base amongst instructors. The existence of agreement between DIs will rule out the knowledge explanation and will indicate a problematic transfer of knowledge to NDs. This problematic knowledge will result NDs not to have similar prioritisations as DIs. The aim of this paper is to investigate the above by using a questionnaire that will address those issues.

The Driver Prioritisation Questionnaire (DPQ) is an exploratory questionnaire study that uses representations of driving scenarios. Participants have to provide rankings of the visual fields for each given driving scenario. First, we predict that DIs will show consistency in their prioritisation hierarchies, suggesting that as a group they have access to the optimum hierarchies for optimal scenarios. Secondly, DIs priority hierarchies will differ to those of NDs. It is predicted that if NDs lack explicit knowledge of where to look in specific scenarios, then group differences will be noted. Finally we predict that, at least for DIs, some aspects of this visual scene will be prioritised above other aspects, when compared to chance. This will demonstrate that prioritisation, rather than random selection, is actually occurring.

2. Method

2.1. Participants

Eighty-eight driving instructors (DIs) took part in this study (22 females). The DIs’ mean age was 42.9 years. The mean driving experience was 24.2 years. On average they had 6.4 years as driving instructors. Instructors were practicing their profession across the UK. The second experimental group consisted of 70 novice drivers (NDs) with 47 females in that group. The mean age was 23.7 years. The average driving experience was 0.9 years. Twenty eight of these were still learner drivers at the time of their participation. Recruitment of participants was done electronically so the chance of a DI being the trainer of a ND was minimal.

2.2. Stimuli and apparatus

The Driver Prioritisation Questionnaire (DPQ) consisted of nine different driving scenarios. The scenarios included: two “Pulling Away” conditions (“Urban” and “Suburban”), two “Dealing with Junctions” conditions (“Give Way” and “Right of Way”), two “Changing Lanes” scenarios (“Urban” and “Dual Carriageway”) and three “General Driving” scenarios (“Urban”, “Dual Carriageway” and “Motorway”). Each driving scenario was represented by a photograph (see Fig. 1 for an example). Each photograph was accompanied with short instructions of what behaviour the driver would be planning in that scenario.

Some photographs were taken from a personal database while others were taken from the Sabre website (http://www.sabre-roads.org.uk/) with the society’s permission. The motivation of using photographs was that they could represent a variety of driving scenarios with certain clarity. The selection of the photographs was done after consultation of driving experts and DIs. Each of the nine photographs reflected a specific driving scenario.

The DPQ was administered in two forms; paper and on-line. The on-line version of the DPQ was advertised at various web-based DIs’ and learner drivers’ forums. The hard copy of the DPQ was printed and distributed through BSM centres to DIs while all NDs completed the online version. Approximately half of the NDs were recruited from a single online learner forum (http://www.2pass.co.uk).

2.3. Procedure

The first part of DPQ asked participants to enter their demographic data. Demographic questions included sex, age, years of driving experience, years of experience as a driving instructor or number of lessons as learner. The second part of DPQ presented nine driving scenarios. Each scenario was represented by a separate photograph, followed by eight visual field categories including “Road Ahead”, “Side Roads/Adjoining Lane”, “Off-Road Task-Relevant Information”, “Side Mirrors”, “Rear View Mirror”, “Blind Spot”, “Contraflow Lane/On coming Traffic” and “In-Car Controls” (see Fig. 1 for an example). The selection of the visual fields was reviewed by driving experts and DIs (who did not take part in the study themselves) prior to inclusion in the questionnaire. It was concluded that those visual fields provide an adequate representation of the generic visual fields that the driver was likely to choose between in each scenario.

1) PULLING AWAY - URBAN ROAD

Scenario Description: The driver is inside the parked car (circled) and has to pull away and continue on the road ahead.

Below there are eight areas of the driver's visual scene. You should rank them between 1 and 8. Number 1 represents the area that you think should be looked at least in comparison to the rest of the categories. In contrast, 8 represents the area that the driver should look most in order to complete this task with safety and efficiency. Please rank all eight areas. You should **not give** the same ranking number twice.

Visual Scene Description	Ranking
4a) Road Ahead	
4b) Side Roads	
4c) "Off - Road Task - Relevant Information" (e.g. pedestrians)	
4d) Side Mirrors	
4e) Rear View Mirror	
4f) Blind Spot	
4g) Contraflow Lane / On Coming Traffic	
4h) In Car Controls (e.g. speedometer)	

Fig. 1. Pulling Away–Urban Road driving scenario.

Participants had to rate the visual fields by giving a number from 1 to 8. Number 8 represented the visual field that the driver thought he/she should look the most in the given driving scenario, while number 1 represented the visual field that the driver should look the least. Instructions made it explicitly clear that they should not give the same ranking twice. The same procedure was identical across all nine driving scenarios.

2.4. Statistical analysis

The first analysis explored whether DIs and NDs were consistent with their ratings within their groups. Kendall's coefficient of concordance (*W*) was used to measure agreement (Field, 2005) for the rankings of DIs and NDs on visual fields. A significant Kendall's *W* implies that ranking was consistent within group. Also Kendall's coefficient can be used to measure effect size (APA, 2001). Kendall's *W* was calculated for all the scenarios both for DIs and NDs separately.

The second statistical analysis compared DIs ratings to NDs ratings for each individual field within a scenario. Since the data were ordinal, group differences within each scenario were tested by using the non-parametric between subjects Mann–Whitney test (Cooligan, 2004). On each scenario 8 comparisons were performed, one for each visual field hence giving the Bonferroni corrected p value of 0.006.

Another analysis was performed on the separate driver groups to investigate whether there was a significant variation in the ranking of the visual fields within a scenario compared to chance. For this purpose a non-parametric Friedman test was performed for each group at every scenario in order to explore any differences between the visual fields (Howell, 2007). Following any significant Friedman test, post hoc comparisons (Wilcoxon Signed Rank Test) were performed separately for DIs and NDs at each scenario. Each pair compared two visual fields and in order to compare all possible combinations 28 pairs were entered per group on each scenario. This was done in order to explore further which visual fields were ranked significantly differently in

Please cite this article in press as: Konstantopoulos, P., Crundall, D., The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios. Accid. Anal. Prev. (2008), doi:10.1016/j.aap.2008.08.009

G Model
AAP-1738; No. of Pages 12
ARTICLE IN PRESS

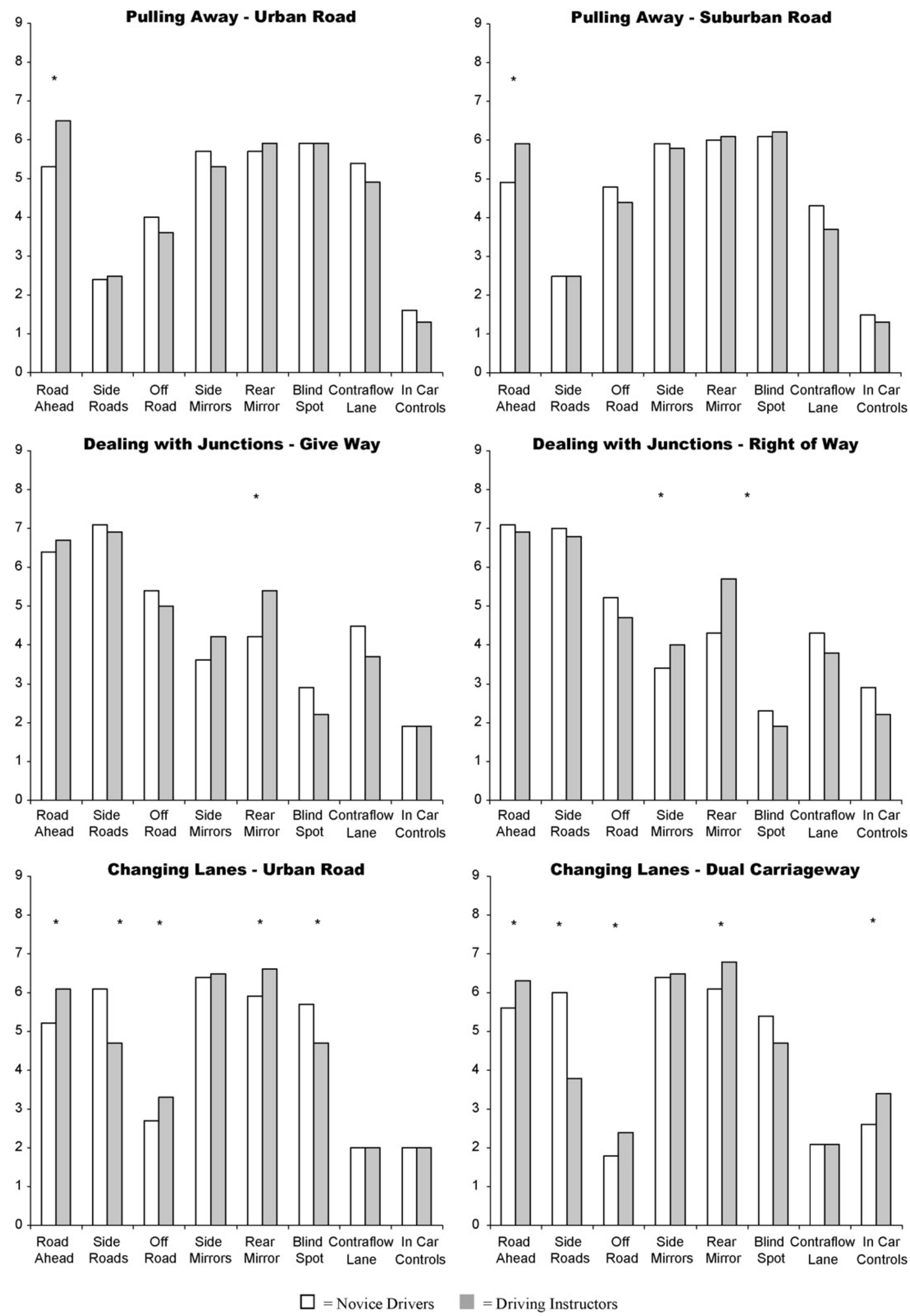

Fig. 2. Mean rankings for all visual field categories across six scenarios. Asterisk denotes a significant group difference at $p < 0.006$.

comparison to the others. The p value was Bonferroni corrected to 0.001.

3. Results

The results of each scenario will be discussed separately however the choice of stimuli allows the clustering of the scenarios into four more general categories, "Pulling Away", "Dealing with Junctions", "Changing Lanes" and "General Driving". The following sections will report analyses of the individual scenarios within these categories. The graphical representation for the ranking across scenarios can be found in Figs. 2 and 3. Post hoc comparisons results for DIs are shown in Table 1 and Table 2 shows the results for NDs. In order to further clarify the results section it should be

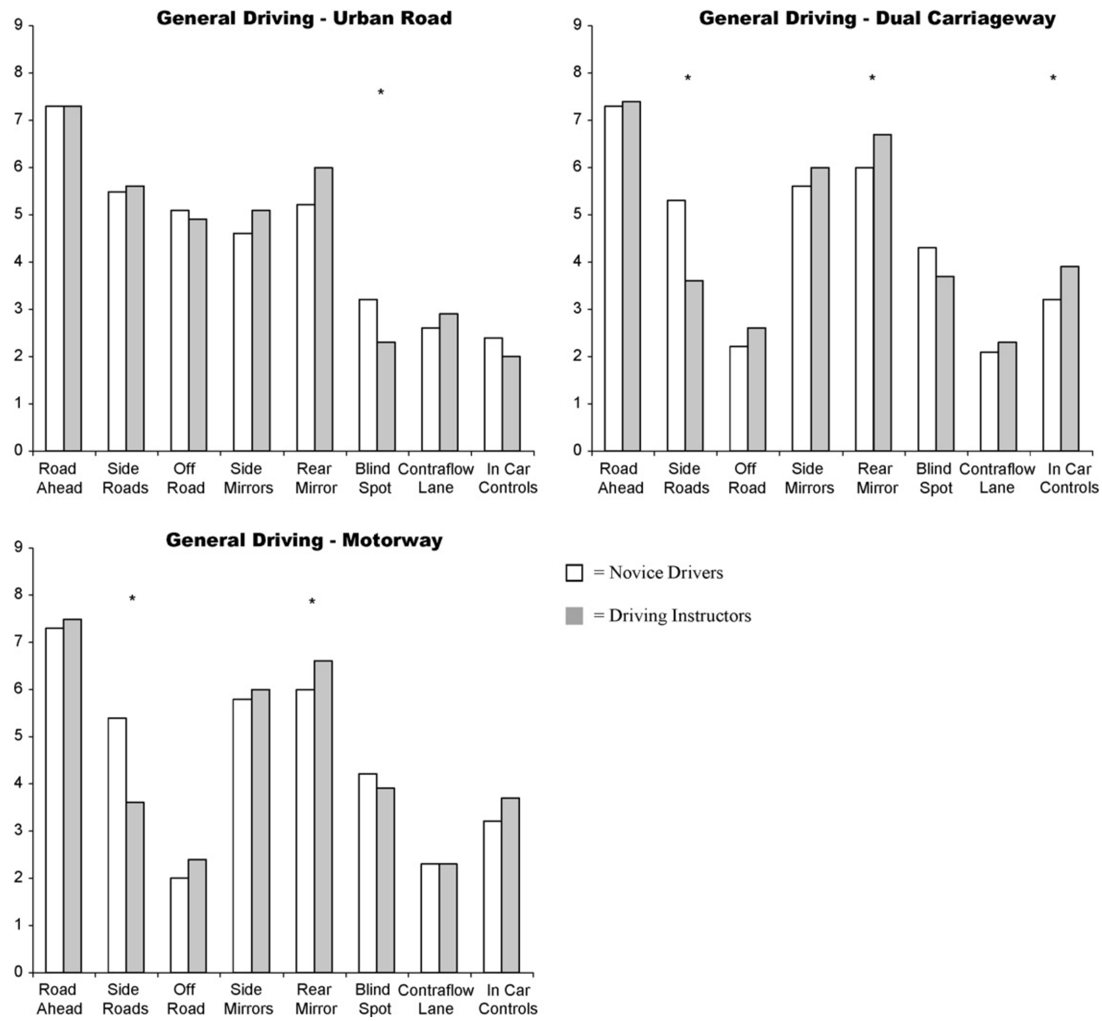

Fig. 3. Mean rankings for all visual field categories across the three general driving scenarios. Asterisk denotes a significant group difference at $p < 0.006$.

mentioned that the term scenario refers to a driving situation (e.g. perform a pulling away manoeuvre) while the term category refers to the visual fields that participants ranked (e.g. road ahead).

3.1. *"Pulling Away"*

The first two scenarios represented a pulling away manoeuvre, either in an urban or suburban setting. For both scenarios the consistency of DIs and NDs rankings was found to be significant and Kendall's W for the urban scenarios was 0.563 ($p < 0.001$) and 0.468 ($p < 0.001$) for DIs and NDs respectively. For the suburban scenario W for DIs was 0.570 ($p < 0.001$) and for NDs 0.471 ($p < 0.001$). This suggests that both DIs and NDs agreed amongst themselves about rankings.

To explore whether there are any differences between the rankings of the DIs and NDs, rankings for each category were compared across groups using Mann–Whitney. For both scenarios the only significant group difference was found for the "Road Ahead" visual field. The mean ranking of the "Road Ahead" visual field was higher for DIs for both the urban (mean rank DIs = 6.5, NDs = 5.3, $U = 1987$, $p < 0.001$) and suburban scenario (mean rank DIs = 5.9, NDs = 4.9, $U = 2025$, $p < 0.001$).

A third analysis checked to see whether the rankings of DIs and NDs formed a pattern that was significantly altered from chance. Friedman tests indicated a significant variation in the ranking of the visual fields for both groups for both the urban scenario (DIs: $\chi^2(7) = 342$, $p < 0.001$; NDs: $\chi^2(7) = 229$, $p < 0.001$) and the suburban scenario (DIs: $\chi^2(7) = 351$, $p < 0.001$; NDs: $\chi^2(7) = 230$, $p < 0.001$)

In order to assess which visual fields differed in prioritisation a series of post hoc Wilcoxon tests were performed for each scenario, with a corrected alpha level of $p = 0.001$. When differences were not found between two or more visual fields they are considered to form a cluster of equal priority categories. The first notable cluster for both scenarios includes "Road Ahead", "Side Mirrors", "Rear View Mirrors" and "Blind Spot" could be clustered together and have been ranked higher than the rest of the fields. While the remaining visual fields were at the low end of the ranking with "Side Roads/Adjoining Lane" and "In-Car Controls" ranked the lowest forming another cluster.

In addition to the findings described above there are unique characteristics for each of the two scenarios. In regard to the urban scenario DIs ranked "Rear View Mirrors" significantly higher than "Side Mirrors" while NDs did not. Also DIs ranked "Contraflow Lane/On Coming Traffic" significantly lower than "Rear View Mirror" while those fields did not differ significantly in NDs ranks. One final difference in the urban scenario was the higher ranking of "Blind Spot" than "Contraflow Lane/On Coming Traffic" as it was scored by DIs while NDs considered those fields to have the same priority as it was found by statistical significance. Regarding the suburban road only one difference was noted with DIs ranking

Table 1
Wilcoxon Signed Pair Test comparisons for visual field rankings of driving instructors within scenario

Scenario	Visual field	Significant comparisons table – driving instructors						
		Road Ahead	Side Roads	Off Road Task	Side Mirrors	Rear View Mirror	Blind Spot	Contraflow Lane
Pulling Away–Urban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	×	*	*	*			
	Blind Spot	×	*	*	×	×		
	Contraflow Lane	*	*	*	×	*	*	
	In-Car Controls	*	*	*	*	*	*	*
Pulling Away–Suburban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	×	*	*				
	Rear View Mirror	×	*	*	×			
	Blind Spot	×	*	*	×	×		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	*	*	*	*	*	*
Dealing with Junctions–Give Way	Side Roads	×						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	×	*			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	*	×	*	*	
	In-Car Controls	*	*	*	*	*	×	*
Dealing with Junctions–Right of Way	Side Roads	×						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	*	*			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	*	×	*	*	
	In-Car Controls	*	*	*	*	*	×	*
Changing Lane–Urban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	×	*	*				
	Rear View Mirror	×	*	*	×			
	Blind Spot	*	×	*	*	*		
	Contraflow Lane	*	*	*	*	*	*	
	In-Car Controls	*	*	*	*	*	*	×
Changing Lane–Dual Carriageway	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	×	*	*	×			
	Blind Spot	×	×	*	*	*		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	×	*	*	*	*	*
General Driving–Urban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	×	×				
	Rear View Mirror	*	×	*	*			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	*	*	*	×	
	In-Car Controls	*	*	*	*	*	×	*
General Driving–Dual Carriageway	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	*	*			
	Blind Spot	*	×	*	*	*		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	×	*	*	*	×	*
General Driving–Motorway	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	*	*			
	Blind Spot	*	×	*	*	*		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	×	*	*	*	×	*

* Significant, $p < 0.001$.

Please cite this article in press as: Konstantopoulos, P., Crundall, D., The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios. Accid. Anal. Prev. (2008), doi:10.1016/j.aap.2008.08.009

Table 2
Wilcoxon Signed Pair Test comparisons for visual field rankings of novice drivers within scenario

Scenario	Visual field	Significant comparisons table – novice drivers						
		Road Ahead	Side Roads	Off Road Task	Side Mirrors	Rear View Mirror	Blind Spot	Contraflow Lane
Pulling Away–Urban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	×	*	*				
	Rear View Mirror	×	*	*	×			
	Blind Spot	×	*	*	×	×		
	Contraflow Lane	×	*	*	×	×	×	
	In-Car Controls	*	*	*	*	*	*	*
Pulling Away–Suburban Road	Side Roads	*						
	Off Road Task	×	*					
	Side Mirrors	×	*	×				
	Rear View Mirror	×	*	*	×			
	Blind Spot	*	*	*	×	×		
	Contraflow Lane	×	*	×	*	*	*	
	In-Car Controls	*	*	*	*	*	*	*
Dealing with Junctions–Give Way	Side Roads	×						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	*	×			
	Blind Spot	*	*	*	×	*		
	Contraflow Lane	*	*	×	×	×	*	
	In-Car Controls	*	*	*	*	*	×	*
Dealing with Junctions–Right of Way	Side Roads	×						
	Off Road Task	*	*					
	Side Mirrors	*	*	*				
	Rear View Mirror	*	*	×	*			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	×	×	×	*	
	In-Car Controls	*	*	*	*	*	×	*
Changing Lane–Urban Road	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	×	*				
	Rear View Mirror	×	×	*	×			
	Blind Spot	×	×	*	×	×		
	Contraflow Lane	*	*	*	*	*	*	
	In-Car Controls	*	*	*	*	*	*	×
Changing Lane–Dual Carriageway	Side Roads	×						
	Off Road Task	*	*					
	Side Mirrors	×	×	*				
	Rear View Mirror	×	×	*	×			
	Blind Spot	×	×	*	*	×		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	*	*	*	*	*	×
General Driving–Urban Road	Side Roads	*						
	Off Road Task	*	×					
	Side Mirrors	*	×	×				
	Rear View Mirror	*	×	×	×			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	*	*	*	×	
	In-Car Controls	*	*	*	*	*	×	×
General Driving–Dual Carriageway	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	×	*				
	Rear View Mirror	*	×	*	×			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	*	*	*	*	×	*
General Driving–Motorway	Side Roads	*						
	Off Road Task	*	*					
	Side Mirrors	*	×	*				
	Rear View Mirror	*	×	*	×			
	Blind Spot	*	*	*	*	*		
	Contraflow Lane	*	*	×	*	*	*	
	In-Car Controls	*	*	*	*	*	×	×

* Significant, $p < 0.001$.

"Side Mirrors" significantly higher than "Off Road Information" while NDs ranked those visual fields statistically the same.

3.2. "Dealing with Junctions"

As it was mentioned there were two "Dealing with Junctions" scenarios, one represented a "Give Way" junction while the second a "Right of Way" junction. For both scenarios ranking consistency was found to be significant and Kendall's W for the "Give Way" scenarios was 0.573 ($p < 0.001$) and 0.501 ($p < 0.001$) for DIs and NDs respectively. For the "Right of Way" scenario W for DIs was 0.6 ($p < 0.001$) and NDs 0.582 ($p < 0.001$).

Regarding the group differences in the rankings for both scenarios, DIs ranked "Rear View Mirror" higher than NDs, for "Give Way" (mean rank DIs = 5.4, NDs = 4.2, $U = 2701$, $p < 0.001$) and "Right of Way" (mean rank DIs = 5.7, NDs = 4.3, $U = 1504$, $p < 0.001$).

Friedman tests indicated a significant variation in the ranking of the visual fields for both groups for both the "Give Way" scenario (DIs: $\chi^2(7) = 353$, $p < 0.001$; NDs: $\chi^2(7) = 245$, $p < 0.001$) and the "Right of Way" scenario (DIs: $\chi^2(7) = 361$, $p < 0.001$; NDs: $\chi^2(7) = 277$, $p < 0.001$).

For both groups the post hoc comparisons showed that for both scenarios "Road Ahead" and "Side Roads/Adjoining Lane" formed a cluster as they were both ranked significantly higher than all the other categories though they did not differ from each other. "In-Car Controls" and "Blind Spot" were significantly lower in all comparisons forming a cluster at the lower end of the scale. Different patterns were also noted for DIs and NDs. DIs did not differentiate their priorities between "Off Road Information" and "Rear View Mirror" while NDs scored "Rear View Mirror" significantly lower. DIs ranked "Off Road Information" higher than "Contraflow Lane/On coming Traffic" while NDs ranked these fields the same in statistical terms. DIs considered the "Rear View Mirror" to have higher priority than "Contraflow Lane/On coming Traffic" while NDs did not differentiate significantly between these categories in these average rankings.

In regards to the "Give Way" scenario specifically, it was found that DIs ranked "Side Mirrors" significantly lower than "Rear View Mirror" and higher than "Blind Spot". In opposition NDs prioritise "Side Mirrors" to an equal extent as the "Rear View Mirror" and "Blind Spot" as shown by statistical significance.

In the "Right of Way" scenario DIs ranked "Side Mirrors" (mean rank DIs = 4, NDs = 3.4, $U = 2213$, $p < 0.006$) higher than NDs. Post hoc comparisons for this scenario showed that DIs did not differentiate statistically their priorities between "Off Road Information" and "Rear View Mirror" while ND scored "Rear View Mirror" significantly lower. DIs scored "Off Road Information" higher than "Contraflow Lane/On coming Traffic" while NDs ranked those fields statistically similarly. Also DIs considered the "Rear View Mirror" to have higher priority than "Contraflow Lane/On coming Traffic" while NDs did not significantly differentiate between them.

3.3. "Changing Lanes"

The next two scenarios represented a situation on which drivers have to change lanes either on an urban road or in a dual carriageway. For both scenarios ranking consistency was found to be significant and Kendall's W for the urban scenario was 0.583 ($p < 0.001$) and 0.631 ($p < 0.001$) for DIs and NDs respectively. For the dual carriageway scenario W for DIs was 0.578 ($p < 0.001$) and NDs 0.625 ($p < 0.001$).

Regarding the investigation of any group differences on the rankings, Mann–Whitney showed that for both scenarios, DIs ranked "Road Ahead" higher than NDs, in the urban scenario (mean rank DIs = 6.1, NDs = 5.2, $U = 2236$, $p < 0.006$) and dual carriageway (mean rank DIs = 6.3, NDs = 5.6, $U = 2314$, $p < 0.006$). DIs ranked "Side Roads/Adjoining Lane" lower than NDs for both the urban (mean rank DIs = 4.7, NDs = 6.1, $U = 1577$, $p < 0.001$) and the dual carriageway (mean rank DIs = 3.8, NDs = 6, $U = 1367$, $p < 0.001$). "Off Road Information" was ranked higher by DIs than NDs in the urban scenario (mean rank DIs = 3.3, NDs = 2.7, $U = 2174$, $p = 0.001$) and dual carriageway (mean rank DIs = 2.4, NDs = 1.8, $U = 2080$, $p = 0.001$). The ranking for "Rear View Mirror" was significantly higher for DIs than NDs for both urban scenario (mean rank DIs = 6.6, NDs = 5.9, $U = 2220$, $p < 0.006$) and dual carriageway (mean rank DIs = 6.8, NDs = 6.1, $U = 1998$, $p < 0.001$) scenario.

Friedman tests indicated a significant variation in the ranking of the visual fields for both groups for both the urban scenario (DIs: $\chi^2(7) = 359$, $p < 0.001$; NDs: $\chi^2(7) = 309$, $p < 0.001$) and the dual carriageway scenario (DIs: $\chi^2(7) = 355$, $p < 0.001$; NDs: $\chi^2(7) = 306$, $p < 0.001$).

For both scenarios "Rear View Mirror", "Side Mirrors", "Blind Spot", "Road Ahead" and "Side Roads/Adjoining Lane" clustered together scored higher according to all participants, than the remaining three fields. Pairwise comparisons showed that DIs ranked both "Side Mirror" and "Rear View Mirror" significantly higher than "Side Roads/Adjoining Lane" while NDs prioritised "Side Roads/Adjoining Lane", "Side Mirrors" and "Rear View Mirrors" to an equal extent in statistical terms. DIs prioritised "Rear View Mirror" higher than "Blind Spot" while NDs did not rank "Rear View Mirror" and "Blind Spot" significantly different.

In regards to the urban scenario an additional group difference was found with the "Blind Spot" visual field ranked significantly lower by DIs than NDs (mean rank DIs = 4.7, NDs = 5.7, $U = 2102$, $p = 0.001$). Post hoc comparisons in the urban scenario showed that DIs ranked "Side Mirrors" higher than "Blind Spot" while NDs' ranking showed no statistical difference between these fields. DIs ranked "Road Ahead" higher than "Blind Spot" while those fields were ranked statistically the same by NDs. DIs did not ranked differently "Road Ahead" with "Side Mirrors" while NDs ranked "Side Mirrors" higher.

Regarding the dual carriageway scenario the "In-Car Controls" visual field was ranked significantly higher by DIs (mean rank DIs = 3.4, NDs = 2.6, $U = 2135$, $p = 0.001$) than NDs. Wilcoxon Signed Rank Test for the dual carriageway scenario showed that DIs had no significant difference between "Side Roads/Adjoining Lane" and In-Car Controls" while NDs ranked "In car Controls" lower than "Side Roads/Adjoining Lane". As a consequence of the low ranking of "In-Car Controls" by NDs no significant difference was found with "Contraflow Lane/On coming Traffic" while DIs ranked "In-Car Controls" higher. DIs ranked "Side Roads/Adjoining Lane" lower than "Road Ahead" although NDs showed no statistical difference. DIs ranked "Road Ahead" significantly higher than "Side Roads/Adjoining Lane" and NDs showed no significant difference. NDs ranked side mirror higher than road ahead while these fields were ranked statistically the same by DIs.

3.4. "General Driving"

General driving scenarios presented a photo of an urban, dual carriageway or motorway driving situation with moderate traffic. Observation of the results showed that the general driving does not provide a common framework for all three scenarios since the urban road scenario has a different pattern of results. Despite the variation in the results across scenarios there was a significant ranking consistency. For the urban scenario W was 0.592 ($p < 0.001$) and 0.469 ($p < 0.001$) for DIs and NDs respectively. For the dual carriageway scenario W for DIs was 0.619 ($p < 0.001$) and NDs 0.586

Please cite this article in press as: Konstantopoulos, P., Crundall, D., The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios. Accid. Anal. Prev. (2008), doi:10.1016/j.aap.2008.08.009

($p < 0.001$). Finally for the motorway scenario values were 0.641 ($p < 0.001$) and 0.59 ($p < 0.001$) for DIs and NDs respectively.

Friedman tests indicated a significant variation in the ranking of the visual fields for both groups for the urban scenario (DIs: $\chi^2(7) = 364$, $p < 0.001$; NDs: $\chi^2(7) = 229$, $p < 0.001$), the dual carriageway scenario (DIs: $\chi^2(7) = 381$, $p < 0.001$; NDs: $\chi^2(7) = 287$, $p < 0.001$) and the motorway scenario (DIs: $\chi^2(7) = 395$, $p < 0.001$; NDs: $\chi^2(7) = 289$, $p < 0.001$).

In the urban scenario the only group difference was found at the "Blind Spot" visual field, with DIs ranking this lower than NDs (mean rank DIs = 2.3, NDs = 3.2; $U = 2011$, $p < 0.001$). Pairwise comparisons for the urban scenario showed that "Road Ahead" was significantly highest in all comparisons for both groups. DIs ranked "Side Roads/Adjoining Lane" and "Rear View Mirror" higher than "Off Road Information" while NDs did not differentiate significantly between these categories. DIs ranked "Rear View Mirror" higher than "Side Mirrors" while NDs did not differentiate statistically between "Side Mirrors" and "Rear View Mirror". Finally, DIs ranked higher "Contraflow Lane/On coming Traffic" than "In Car Controls while NDs did not shown significant difference between "Contraflow Lane/On coming Traffic" and "In Car Controls".

For dual carriageway and motorway scenarios some specific group differences were found. DIs ranked "Side Roads/Adjoining Lane" field lower than NDs in dual carriageway (mean rank DIs = 3.6, NDs = 5.3; $U = 1492$, $p < 0.001$) and motorway scenario (mean rank DIs = 3.6, NDs = 5.4; $U = 1391$, $p < 0.001$). The "Rear View Mirror" was ranked by DIs higher than NDs for both dual carriageway (mean rank DIs = 6.7, NDs = 6; $U = 2043$, $p < 0.001$) and motorway scenario (mean rank DIs = 6.6, NDs = 6; $U = 2075$, $p < 0.001$).

Post hoc comparisons showed that "Road Ahead" was significantly higher than the other items for both groups and scenarios. It was also revealed that "Contraflow Lane/On coming Traffic" and "Off–Road Task–Information" ranked significantly lower than any other item.

For both dual carriageway and motorway scenarios DIs ranked "Rear View Mirror" higher than "Side Mirrors" while NDs did not rank "Side Mirrors" and "Rear View Mirrors" significantly different. Also the "Side Roads/Adjoining Lane" did not differ significantly from "Side Mirrors" and "Rear View Mirror" for NDs while "Rear View Mirror" was significantly higher for DIs. DIs ranked "Side Roads/Adjoining Lane" statistically the same with "Blind Spot" and "In Car Control", while NDs ranked "Side Roads/Adjoining Lane" higher in both scenarios.

Regarding the dual carriageway scenario the "In-Car Control" category was ranked higher by DIs than NDs (mean rank DIs = 3.9, NDs = 3.2; $U = 2295$, $p < 0.006$). Wilcoxon comparisons showed that for the dual carriageway scenario DIs ranked "Contraflow Lane/On coming Traffic" lower than "In-Car Controls" while NDs did not differentiate significantly between these two fields.

4. Discussion

4.1. Consistency

The first question addressed by this research was whether DIs and NDs will show a ranking consistency. Rather than selecting "correct" areas of the visual scene a priori we allowed participants to choose their own areas of prioritisation and judged the "correctness" of their knowledge via the consistency of the ratings across the group. This is based on the assumption that if DIs show consistency within group then we can assume that they select the optimum priority for each scenario. One might argue that group consistency does not necessarily reflect efficient strategies. However, as inexperienced drivers have a greater crash liability, it is highly likely that DIs are behaving in a way that contributes to their safety. One still might argue however that group consistency could still reflect a consistent error of insight on the DIs part: while they may perform behaviours x, y and z to stay safe, a systematic failure of insight may lead them all to believe that they perform the behaviours a, b and c. While this is an unlikely scenario, it can still be ruled out by comparing the ratings of DIs to actual observed behaviour in previous studies of eye tracking while driving. This link between eye tracking studies and the present findings will be discussed below.

In terms of the results Kendall's coefficient of concordance showed that there was an overall consistency across DIs. Surprisingly NDs' results showed similar levels of consistency to that of the DIs indicating that NDs do agree with each other regarding where they should look, though this agreement does not mean that they choose the same categories as DIs. In fact, as the later results show there are considerable differences between DIs and NDs. The high consistency of DIs rankings suggest that DIs have sufficient introspection into the optimum visual strategies for specific scenarios, which should provide them with the knowledge base which they can then pass on to their students. Regarding NDs the present findings show that they possess a sort of a common knowledge regarding visual field prioritisation which possibly derived from their driving training.

4.2. Group differences

Group differences were explored by using Mann–Whitney test. Results showed that most group differences occurred in both "Changing Lanes" scenarios with five visual fields found to be significantly different between groups. One possible explanation for the numerous differences in the "Changing Lanes" scenarios might be the fact that NDs have not had such experience on the road because the scenarios involved changing lanes on multiple lane roads. Novice drivers are typically more likely to be overtaken on these roads than to be making an overtaking manoeuvre themselves. Thus, they might not be aware of the optimum prioritisations required for those particular scenarios. The remaining scenarios found differences between DIs and NDs in one, two or three categories.

An alternative way to look at group differences is to sum the frequency of the differences between DIs and NDs for each visual field across the nine scenarios. It was found that DIs ranked "Rear View Mirror" higher than NDs across six scenarios (Fig. 4 illustrates group differences across three visual categories). "Side Roads/Adjoining Lane" and "Road Ahead" were found different between groups in four scenarios. Interestingly results showed a very consistent pattern as DIs ranked "Rear View Mirror" higher on all the scenarios that this group difference was found. The results suggest that DIs did not pass their knowledge on NDs perhaps because of a failure in training. Also DIs had a higher ranking on all scenarios for "Road Ahead" compared to NDs. Finally, "Side Roads/Adjoining Lane" was ranked differently between group with DIs ranking this lower than NDs. These group differences inform the debate as to why NDs have improvised visual search (Crundall and Underwood, 1998). The results suggest that NDs lack the same priorities as DIs, suggesting a lack of knowledge. This fits with previous research (Underwood et al., 2002) which showed that NDs poor visual search was not due to the demands of having to control the car, but instead stems form lack of understanding of the dangers in certain scenarios.

4.3. Scenarios

In addition to group differences, a variation of prioritisation between categories was observed within all the scenarios. In statistical terms the Friedman test clearly demonstrated that within

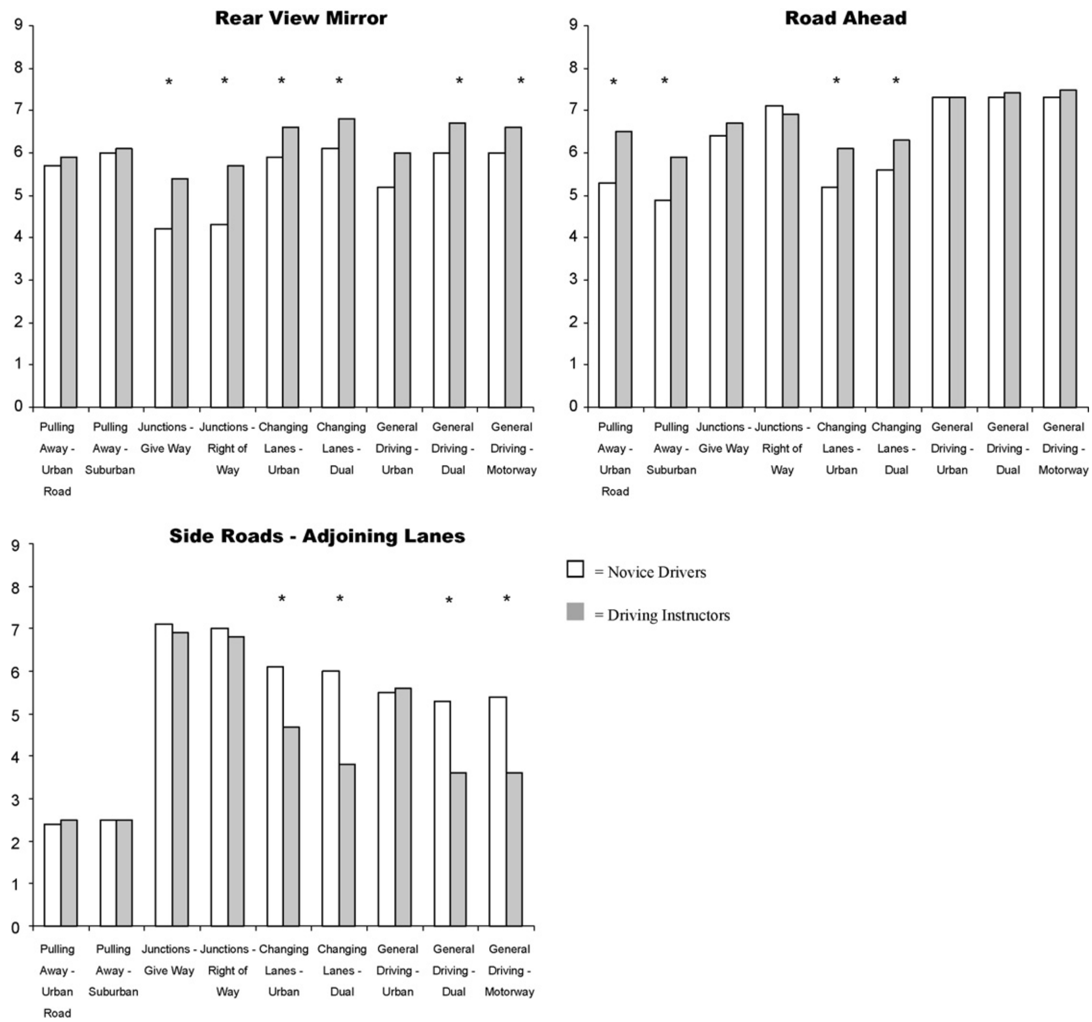

Fig. 4. Mean rankings for three visual field categories across the nine scenarios. Asterisk denotes a significant group difference at $p < 0.006$.

all scenarios the priority ratings differed significantly compared to chance, suggesting that certain categories were favoured over others dependent on the particular scenario. The Wilcoxon comparisons revealed the subsequent differences between the visual field categories on each scenario.

The results for the "Pulling Away" scenarios indicated a specific prioritisation pattern. DI's think "Road Ahead" is a more important region to look at when the driver is pulling away compared to NDs. The NDs however, cluster the "Road Ahead" category with other visual fields in contrast with DI's rankings. This difference on those two scenarios might be explained by the fact that the usual driving mnemonics for a pulling away manoeuvre refer to mirror, signal and manoeuvre. This explicit teaching tool may lead NDs to under prioritise the road ahead.

For "Dealing with Junctions" scenarios participants provided prioritisation rankings that are clearly understandable in the context. It seems sensible that "Road Ahead" and "Side Roads/Adjoining Lane" are the most critical locations when approaching a junction. The "Blind Spot" possibly received a very low ranking because the photographs represented a single lane carriageway, with less possibility of a vehicle overtaking from behind. Also the drivers in these scenarios are not likely to change lanes, hence the low ranking of "Blind Spot". Post hoc comparisons for both scenarios revealed that the main difference between groups is that NDs in general had lower rankings than DIs for "Rear View Mirror" failing to differentiate from "Side Mirrors". Results suggest that DIs inspect and prioritise "Rear View Mirror" differently than "Side Mirrors" depending on context. However this optimum prioritisation has not been transferred to NDs since they seem not to distinguish significantly between these two categories even when there is no cognitive demand like the filling of DPQ.

For scenarios involving "Changing Lanes" the explanation for the low ranking of the "Contraflow Lane/On coming Traffic" item can be attributed to the fact that the opposing lane was separated from the driver's lane by a central reservation. This is standard for motorways, and is increasingly common with multiple lane carriageways. The high ranking of both "Side Mirrors" and "Rear View Mirror" is task specific. The safety of changing lanes is highly dependent on the driver knowing what other road users are immediately to the rear or side of the vehicle. As it was mentioned above those two scenarios have the most group differences indicating an unfamiliar context for NDs. Also a similar pattern of results was found in the post hoc comparisons regarding "Rear View Mirror" and "Side Mirrors" with DIs having higher rankings than NDs.

The final three scenarios represented general driving across urban roads, dual carriageways, and motorways. According to all participants the "Road Ahead" location is the most important when driving along urban roads. In contrast "In-Car Controls" should be the least looked-at location. For the dual carriageway and motorway scenarios the low ranking of "Contraflow Lane/On coming

Traffic" and "Off–Road Task–Relevant Information" might have occurred because motorways do not usually have pedestrians and there is a central reservation between lanes of opposite direction. In most other scenarios the "In-Car Controls" category had the lowest prioritisation. That was not the case for the dual carriageway and motorway scenarios which had much higher prioritisation. This is possibly due to the greater speed on these roads requiring more frequent speed checks. Observation of the results showed that both DIs and NDs clearly distinguished their priorities between urban driving and driving on both high speed roads. Both groups ranked lower "Side Mirrors", "Rear View Mirror", "Blind Spot" and "In Car Controls" in the "General Driving–Urban" than the other two scenarios.

Overall the results showed that "Road Ahead", "Side Mirror" and "Rear View Mirrors" were in most cases significantly higher than the rest of the given visual categories. Also those visual fields produced the most group differences and significant comparisons. "In-Car Controls" was the lowest ranked with the exception of the scenarios that involved driving on high speed roads. While the "In-Car Controls" category did not distinguish the speedometer from other in-car controls, this result ostensibly suggests that all drivers recognise the need for speed management on higher speed roads. "Off–Road Task–Relevant Information" item was ranked low but it was probably due to the fact that photos of DPQ did not contain any immediately threatening off-road stimuli such as pedestrians. The low ranking of those visual fields could be explained by previous research findings (Yarbus, 1967) indicating that certain locations becoming visually important according to task demands. "Side Roads/Adjoining Lane" and "Blind Spot" items were usually in the middle of the ratings dependent on the scenario.

4.4. General discussion

Results showed that DIs are consistent and choose patterns of prioritisation that differ from chance and are scenario specific. This suggests that DIs have explicit shared knowledge of the optimum visual search. Whether this agreement is based entirely in explicit knowledge or the DPQ acted as knowledge elicitation material is not clear. Previous research (Hoffman et al., 1995) has shown that rating tasks elicit knowledge from experts and moreover they showed differences between experts and novices. Hence it is possible that the DPQ acted as a cue for DIs to externalise their existing knowledge.

NDs are also consistent and have patterns that diverge from chance but have many differences with DIs. This suggests that they all agree to look in the wrong places. They must all be following the same guidelines—either an incorrect informed model (based on DIs advice, but this result in wrong prioritisations—mirror, signal manoeuvre) or they are using a "naïve model" to guide their priorities. In other words, when pulling away, even non-drivers will realise that it is important to use mirrors and look over the shoulder etc. A naïve model will not include the less obvious priorities however. It is likely that reality involves a mixture of these problems.

DIs and NDs differ and since NDs are under no demands when completing the DPQ it suggests that although DIs have this knowledge NDs are not benefiting. This suggests that driving training is not enough to transfer knowledge from DIs to NDs. This might be due to failing of DIs to choose the appropriate technique or maybe due to resource limitations of the NDs when in the learning situation. It is possible that learning during on-road lessons might be problematic due to poor encoding. For example when a learner is performing a pulling away manoeuvre and the DI will instruct the mirror, signal, manoeuvre directions it is possible that the learner will concentrate more in performing the task rather than encoding any specific directions. A possible solution to this problem might be some classroom instruction.

Our results are consistent with previous research findings (Underwood et al., 2003). They found no road type difference between rural, suburban and dual carriageway between "Road Near Ahead", "Road Mid Ahead" and "Road Far Ahead" as calculated by mean fixation duration. Overall they found that "Road Far Ahead" and "Road Mid Ahead" visual fields had the more fixations than the rest of their defined fields. This is the case for our results since the "Road Ahead" category was significantly amongst the highest ranked categories in most scenarios.

Underwood et al. (2003) reported increase mirror fixations on dual carriageways than rural and suburban roads. Again both mirror visual fields where highly rated by both DIs and NDs. Although as it was mentioned NDs rated significantly "Rear View Mirror" significantly lower in six scenarios. Another study (Pastor et al., 2006) investigated the relationship between state of alertness and mirror inspection. Their most interesting finding in relation to our results is the mirror inspection between motorway and one lane road driving where they found a higher frequency of mirror inspection on motorways than roads. The results of those studies match the results of the present study where we found that "Side Mirror" and "Rear View Mirror" were significantly higher at "Dual Carriageway" and "Motorway" general driving scenarios than "Urban" general driving.

On the experimental level we propose that future driving training interventions should consider the preference on "Road Ahead", "Side Mirrors" and "Rear View Mirrors". We believe that the consequence of that will increase both horizontal and vertical scanning as well as increase the level of alertness (Pastor et al., 2006). In applied terms DIs themselves could benefit by the results of the DPQ. Regardless of the efficiency of the existing training system, DIs could enhance their teaching strategies by considering the findings of DPQ. For example DIs could teach alternative ways of speed estimation without inspection of in-car controls. It seems that certain visual fields priorities knowledge has not been transferred to NDs by DIs during training. It would be beneficial if DIs focus more on their explicit instructions to those areas. At last it could be said that by involving DIs into the experimental psychological research we might increase their awareness regarding the cognitive aspects of visual search. Also by comparing DIs and NDs, the two extremes of driving experience have been explored.

DIs have knowledge regarding visual search priorities but NDs do not have same knowledge. This discrepancy indicates failure of DIs to transfer this specific knowledge. Perhaps classroom teaching without driving demands might resolve part of the problem. Training of specific scenarios would benefit from our findings such as further emphasising use of mirrors, encouraging NDs to reduce time of in-car controls and highlighting the need to pay attention to the road ahead even when performing a pulling away manoeuvre.

Despite the relatively low number of participants it can be argued that the exploratory scope of the questionnaire has been achieved. Hopefully future studies with the DPQ will replicate these effects on larger sample. Another way of investigating further the topic would be the measurement of eye movements of DIs and NDs. Eye movements could reveal a different pattern in relation to other studies that used experienced drivers. Also it would be a point of interest to compare participants' opinions between a theoretical questionnaire and behavioural data from simulated driving or by using an instrumented vehicle. Future investigations might extend present findings by investigating gender differences in insights on visual search. For instance it was found that women report greater problems in spotting motorcycles while driving (Crundall et al., 2008). As a final remark it should be mentioned that the involvement of driving instructors into applied driving research would

Please cite this article in press as: Konstantopoulos, P., Crundall, D., The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios. Accid. Anal. Prev. (2008), doi:10.1016/j.aap.2008.08.009

lead to more interesting findings and increase our understanding regarding drivers' visual allocation.

Acknowledgements

We would like to thank Susan McCormack and Steve Trawley for their help during the recruitment of participants.

References

APA, 2001. Publication Manual of the American Psychological Association, 5th ed.

Clarke, D.D., Ward, P., Truman, W., 2005. Voluntary risk taking and skill deficits in young driver accidents in the UK. Accident Analysis and Prevention 37 (3), 523–529.

Cooligan, H., 2004. Research Methods and Statistics in Psychology, Hodder Arnold, 4th ed.

Crundall, D., Bibby, P., Clarke, D., Ward, P., Bartle, C., 2008. Car drivers' attitudes towards motorcyclists: a survey. Accident Analysis and Prevention 40 (3), 983–993.

Crundall, D.E., Underwood, G., 1998. Effects of experience and processing demands on visual information acquisition in drivers. Ergonomics 41 (4), 448–458.

Deery, H.A., 1999. Hazard and risk perception among young novice drivers. Journal of Safety Research 30 (4), 225–236.

Field, A.P., 2005. Discovering Statistics Using SPSS. Sage, London.

Hall, J., West, R., 1996. Role of formal instruction and informal practice in learning to drive. Ergonomics 39 (4), 693–706.

Hoffman, R.R., Shadbolt, N.R., Burton, A.M., Klein, G., 1995. Eliciting knowledge from experts—a methodological analysis. Organizational Behavior and Human Decision Processes 62 (2), 129–158.

Howell, D.C., 2007. Statistical Methods for Psychology, 6th ed. Thompson.

Itti, L., Koch, C., 2000. A saliency-based search mechanism for overt and covert shifts of visual attention. Vision Research 40 (10–12), 1489–1506.

Miller, J., Stacey, M., 2006. The Driving Instructor's Handbook, Kogan Page, 14th ed.

Ozkan, T., Lajunen, T., Summala, H., 2006. Driver behaviour questionnaire: a follow-up study. Accident Analysis and Prevention 38 (2), 386–395.

Pastor, G., Tejero, P., Choliz, M., Roca, J., 2006. Rear-view mirror use, driver alertness and road type: an empirical study using EEG measures. Transportation Research Part F: Traffic Psychology and Behaviour 9 (4), 286–297.

Treue, S., 2001. Neural correlates of attention in primate visual cortex. Trends in Neurosciences 24 (5), 295–300.

Underwood, G., 2007. Visual attention and the transition from novice to advanced driver. Ergonomics 50 (8), 1235–1249.

Underwood, G., Chapman, P., Bowden, K., Crundall, D., 2002. Visual search while driving: skill and awareness during inspection of the scene. Transportation Research Part F: Traffic Psychology and Behaviour 5 (2), 87–97.

Underwood, G., Chapman, P., Brocklehurst, N., Underwood, J., Crundall, D., 2003. Visual attention while driving: sequences of eye fixations made by experienced and novice drivers. Ergonomics 46 (6), 629–646.

Yarbus, A.L., 1967. Eye movements during perception of complex objects. In: La, R. (Ed.), Eye Movements and Vision. Plenum Press, New York, pp. 171–196.

Please cite this article in press as: Konstantopoulos, P., Crundall, D., The Driver Prioritisation Questionnaire: Exploring drivers' self-report visual priorities in a range of driving scenarios. Accid. Anal. Prev. (2008), doi:10.1016/j.aap.2008.08.009