

Transport Research Laboratory



Full Time Through Junction Running with Designated Green Lane Simulation Study

by C Diels, A Dale, R Robbins, T Rees & I Summersgill

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by C Diels, A Dale, R Robbins, T Rees & I Summersgill (TRL)

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Support to Managed Motorways Project

Client: Highways Agency

Paul Goward

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Contents

Executive summary	x
1 Introduction	1
2 Method	3
2.1 Participants	3
2.1.1 Age	3
2.1.2 Information provided	3
2.1.3 Vehicle emissions values	3
2.2 Experimental design	4
2.3 Route design	4
2.3.1 General features	4
2.3.2 Route summary	4
2.4 Participant instructions	5
2.5 Measures	5
3 Results	7
3.1 Participant sample	7
3.1.1 Confidence in day-to-day driving and driving on motorways	7
3.2 Driving behaviour	8
3.2.1 Lead in	8
3.2.2 Junction 1	12
3.2.3 Junction 2	13
3.2.4 Junction 3	14
3.2.5 Junction 4	16
3.2.6 Junction 5	16
3.2.7 Junction 6	17
3.3 Questionnaire results	18
E1 - Safety	18
3.3.1 E1a – Driving in general	18
3.3.2 E1b-f – Driving in LBS1-4	18
3.3.3 E1g-h – Leaving the motorway when the hard shoulder is open and rejoining the motorway when the hard shoulder is open	19
3.3.4 E1i – Driving when the national speed limit applied	20
3.3.5 E1j-k – Leaving the motorway from the green lane and rejoining the motorway and making your way over to the green lane	20
3.3.6 E1l – Driving when a 60mph speed limit applied	20
3.3.7 E1m – Driving under conditions in which speed limits differed for different lanes	20
3.3.8 E1n – Approaching a junction	20
3.3.9 E1o – Passing an entrance slip road	21
3.3.10 E1p – Safety when passing, or being passed by another vehicle	21
3.3.11 E1s and E1t – Entering and leaving the green lane	22
3.3.12 E1u-v – Driving with light and heavy traffic	23
3.4 Participants understanding of Green lane	24
3.4.1 F1 – Green lane commencing	24
3.4.2 F2 – Restrictions of green lane	25

3.4.3	Clarity of signs and road markings to indicate where and when to join the green lane	26
3.4.4	F4 – Clarity of lanes permitted to drive in	27
3.4.5	F5 – Clarity of signs and road markings clearly indicating which lanes were permitted to travel in	28
3.4.6	F6a – Which lanes were participants permitted to drive in?	29
3.4.7	F6b – Confidence	30
3.4.8	F7a – Permitted to travel in the green lane if LBS1 is closed?	30
3.4.9	F7b – Confidence	30
3.4.10	F8a -Permitted to travel in the green lane if LBS1 and LBS2 are closed?	30
3.4.11	F8b - Confidence	30
3.4.12	F9 – Did you feel you were overloaded with the number of signs?	31
3.4.13	F10a – Lanes permitted to drive in when the vehicle is in VED band D	31
3.4.14	F10b – Confidence	32
3.4.15	F11a – Lanes permitted to drive in when the vehicle is in VED band B	32
3.4.16	F11b – Confidence	32
3.4.17	F12 – How confident did the participant feel when driving on the motorway that included a green lane?	33
3.4.18	F13a – Participants understanding of whether they were permitted to cross the double white line	34
3.4.19	F13b - Confidence	34
3.4.20	F14a - Permitted to undertake (i)	34
3.4.21	F14b – Confidence	34
3.4.22	F15a – Permitted to undertake (ii)	35
3.4.23	F15b – Confidence	35
3.4.24	F16 – Participants understanding of driving with the green lane in operation	35
3.5	General questions on green lane operation	36
3.5.1	G1 – Overall levels of congestion	36
3.5.2	G2 - Journey times	37
3.5.3	G3 – Predictability of journey times	38
3.5.4	G4 – Environmental conditions	39
3.5.5	G5 – Number of accidents	40
3.5.6	G6 - Severity of accidents	41
4	General discussion	42
4.1	Driving behaviour	42
4.2	Questionnaire	43
4.3	Safety interpretation	43
4.4	Network performance interpretation	45
5	Conclusion	46
	Acknowledgements	47
	References	47
	Glossary of terms and abbreviations	48
	Appendix A – Route summary	49

Appendix B – Questionnaire	51
Appendix C – Participant instructions	57

List of Figures

Figure 1: An example view of the green lane	x
Figure 2: An example view of the green lane scheme.....	1
Figure 3: Participant breakdown. Acronyms in brackets identify each unique group (e.g., 'Y_A_I' refers to the group consisting of Younger, Allowed, and Informed participants)	4
Figure 4: Section division of lead in	8
Figure 5: Diagram illustrating the 3 sections used for the analysis in the lead in (top) and each of the junctions (bottom)	8
Figure 6: Mean lane position for each driver group within Lead-in, all sections.....	9
Figure 7: Mean speed (mph) of participants on approach to the start of the green lane	11
Figure 8: Mean lane position for each participant group (Junction 1).....	12
Figure 9: Mean lane position for each driver group within junction 2	14
Figure 10: Mean lane position for each driver group within junction 3	15
Figure 11: Position of last exit green lane (left) and first entrance LBS1 (right) to leave the motorway at Junction 3 for green lane users	15
Figure 12: Position of first entrance LBS1 for non-green lane users	16
Figure 13: Bar chart showing participants' mean rating of driving safety through the green lane scheme (E1a).....	18
Figure 14: Participants' mean ratings for feelings of safety in a variety of situations (E1b-f).....	19
Figure 15: Participants' mean ratings for feelings of safety when approaching a junction	21
Figure 16: Mean safety ratings for allowed and not allowed participants when overtaking, being overtaken and being undertaken (E1p, q & r).	22
Figure 17: Mean safety entering and leaving the green lane	23
Figure 18: Mean safety scores of driving in heavy and light traffic	24
Figure 19: Frequency of responses for informed and uninformed drivers to the clarity of signs warning of the beginning of the green lane.	25
Figure 20: Frequency of responses for informed and uninformed drivers of awareness of the restrictions that applied for the green lane	26
Figure 21: Frequency of responses for uninformed and informed drivers to the clarity of where and when to join the green lane.....	27
Figure 22: Frequency of responses for uninformed and informed drivers to the clarity of which lanes they were permitted to use.....	28
Figure 23: Frequency of responses for uninformed and informed drivers to the clarity of signs and road markings indicating the lanes in which they were permitted to drive	29
Figure 24: Frequency of participant scores in response to the number of signs	31
Figure 25: Participants' mean confidence scores for driving on the motorway with a green lane operating.....	33
Figure 26: Participants responses to whether they felt held up by other vehicles with the green lane being in operation.....	36

Figure 27: Participants’ responses to the impact of the green lane on overall levels of congestion (G1) 37

Figure 28: Participants responses to the impact of the green lane on journey times (G2) 38

Figure 29: Participants responses to the impact of the green lane on predictability of journey times (G3) 39

Figure 30: Participant responses to the impact of a green lane on environmental conditions (G4) 40

Figure 31: Participants responses to the impact of a green lane on the number of accidents (G5) 41

Figure 32: Participant responses to the impact of a green lane on the severity of accidents (G6) 42

List of Tables

Table 1: FT TJR plus designated lane Route	5
Table 2: Overview of experimental groups.....	7
Table 3: Mean years held licence and mileage last year per age category	7
Table 4: Speed in response to Green lane advance warning signs with start of green lane (section 3)	10
Table 5: Proportion of participants in each group and percentage of total time that participants drove on the green lane access zone	10
Table 6: Use of green lane in lead in section 3 for each participant group	12
Table 7: Proportion of participants in each group and percentage of total time that participants drove on the green lane	13
Table 8: Proportion of green lane users and percentage green lane use for sections 1-3 in Junction 6	17
Table 9: Number of participants who incorrectly answered the lanes in which they were permitted to drive.....	30
Table 10: Number of participants who incorrectly answered which lane a VED band D vehicle is permitted to use	32
Table 11: Number of participants who incorrectly answered which lane a VED band B vehicle is permitted to use	32
Table 12: Participant responses to whether they were permitted to cross the double white line	34

Executive summary

The number of vehicles that occupy the roads is continuing to rise, causing greater pressure on the motorway network. This has crucial implications for the economy and society in turn. Potential solutions are sought to ease congestion and unpredictability of travel times for drivers. These need to be cost effective and cause as little disruption as possible to the motorways. Consequently, it may be advantageous to consider schemes that use current network capacity in a novel manner. The scheme identified for this study is hard shoulder running with full time through junction running (FT TJR) and a designated lane. The designated lane in this study was specified as a 'green' lane.

It would be unrealistic to test the green lane in a real world setting; therefore driving simulation provides a safe and efficient way of addressing these issues. The simulation can replicate that of a real motorway environment in high fidelity in complex traffic conditions, and record each driver's performance in every aspect of their drive. In conjunction with the data from the simulator, custom made questionnaires were designed to elicit participants' subjective experiences of driving with a green lane. The questionnaires combined with the data outputs from the simulator enable a clear picture of how drivers behave and feel during the drive.

The green lane only allows access to drivers who operate vehicles that are below a specific CO₂ g/km emissions output. These lanes would typically be located in areas of high congestion, providing a journey time advantage for those with more efficient vehicles. A screenshot of the green lane as configured in the driving simulator can be seen in Figure 1 below.



Figure 1: An example view of the green lane

No such scheme has been introduced onto the UK network. However, a simulated single lane tolling (SLT) scheme has been trialled at TRL (Diels et al. 2008), bearing some resemblance to this green lane study. The SLT scheme used a designated lane for drivers paying a premium and results this showed that the scheme was used correctly but participants were reluctant to pay the charge. It is essential for this study that the green lane scheme is self explanatory to drivers with signs providing clear understanding of the regulations in place.

72 participants were recruited to take part in the trial and the participant pool was divided equally into eight groups:

- Informed/Uninformed – comparisons were made between those who were briefed of the functions of the green lane prior to driving the simulated scheme to those who were not.
- Allowed use/Not allowed use – half of the drivers who were informed of the green lane were also told that the vehicle they were operating was within the band A –

C specifications and therefore below the CO₂ emissions output threshold for green lane use. The other half were told that their vehicle exceeded the identified emissions output threshold and were therefore not permitted to use the green lane.

- Age –differences between younger and older drivers is well documented and therefore an age split of 17-44 (young) and 45+ (old) was also examined.

Each driver spent approximately an hour at TRL in completing this study. This comprised: a 5-10 minute familiarisation to acquaint them with the vehicle controls, 30 minutes for the trial itself and 20 minutes to complete questionnaires designed to provide insights into participants' subjective impressions of the designated green lane scheme).

Results from the trial revealed that drivers' responses to the green lane were largely in line with expectations and predict positive outcome for such schemes. Most importantly, drivers responded to the green lane in a generally correct and safe manner. Observed levels of illegitimate green lane use decreased as familiarity with the scheme increased. Some evidence of incorrect green lane use was observed. Specifically, the signs indicating the start of the GL were not well understood as some illegal usage of the GL was noted. Post trial questionnaires indicated that uninformed drivers felt significantly less confident in using the scheme. Therefore a public information campaign would serve a dual purpose: to increase the confidence of all drivers and to reduce instances of illegal use.

Before any green lane scheme could be implemented, its safety implications must be considered. The trial outcomes described in this report suggest a limited impact on safety resultant from the implementation of the green lane scheme.

Additionally, the impact on network performance was also considered. It is recommended that to maximise network performance the eligibility criteria for using the green lane should be set so that at least 20% of cars are allowed to use the lane during periods of high flow.

1 Introduction

In response to growing congestion, the Highway Agency (HA) is exploring methods of maximising the capacity of the motorway network without significant changes to the existing infrastructure. One such method is 'hard shoulder running' and its refinements such as 'Through Junction Running' (TJR) whereby traffic is allowed to use the hard shoulder through junctions on either a permanent basis (i.e. full time TJR) or dependent on traffic demand (i.e. part time TJR) (see Diels et al., 2009 a, b).

The HA is now also investigating the feasibility of implementing designated lane schemes on the strategic road network. Designated lane (DL) schemes refer to the use of an additional lane, or fast lane, specifically designated for certain vehicle categories only. One such variant is single lane tolling (SLT) whereby one lane on a standard motorway is allocated as a toll lane which is open only to those motorists who have pre-paid a toll (see Diels et al., 2008). Note that such a scheme differs from toll roads like the M6 (Birmingham) in that it only charges toll for the use of a single lane on an existing motorway.

The aim of this study was to understand driver behaviour in response to the presence of full time through junction running (FT TJR) where a designated lane also features. In this study, the designated lane will be a green lane (GL) that can be used by vehicles below a specified CO₂ g/km emission threshold only. The GL design was based on the design developed for the SLT scheme (see document RPF3 333 'SLT Scheme Design Template'). The scheme contains unique characteristics, such as access/egress zones that are identified with a change of lane marking and novel signs to inform drivers of the status of the green lane (see Figure 2). The scheme design was limited to the roadside aspects of the scheme and did not include other elements such as back office user services and enforcement systems.



Figure 2: An example view of the green lane scheme

Major factors affecting the success of schemes such as the proposed GL scheme are attitudes and opinions, as well as comprehension and compliance of motorists. To investigate driving behaviour and motorists' opinions, a driving simulator study was conducted. Simulation forms a cost-effective and safe medium for this type of evaluation as it allows for a realistic representation of the design to be interactively experienced by drivers in a completely safe environment.

The particular objectives of this study were to evaluate the proposed design of the GL scheme in terms of:

- The clarity of signing and road markings
- Level of contravention

- Drivers' willingness to move onto the 'green lane'
- Impact on motorway exit and entry behaviour
- Driver opinions and attitudes toward the scheme
- Effect of prior knowledge about the scheme's workings

2 Method

2.1 Participants

72 participants were recruited through the TRL participant database to take part in the study. All participants had valid driving licenses and there were no particular inclusion/exclusion criteria based on previous experience of hard shoulder use.

2.1.1 Age

It is known that driving behaviour across the age range varies considerably (e.g. Schlag, 1993). Younger drivers are more likely to engage in lane changing behaviours and drive at faster speeds; Older drivers are less likely to switch lanes and therefore tend not to take as much advantage of the additional lane provided (Diels et al, 2008). Hence, there were two levels of age across participants. An equal number were recruited to the younger (17-44) and older (45+) groups and there was an equal number of males and females in each age group.

2.1.2 Information provided

In addition to age, there were two levels of information provision (informed/uninformed) across participants since driving behaviour and comprehensibility of the GL scheme could be expected to be affected by prior knowledge regarding the scheme (refer to appendix C for verbal instructions).

- *Informed*

Participants were informed about the FT TJR and GL scheme before they started their drive. They received extended information on the workings of the GL scheme.

- *Uninformed*

Participants remained uninformed about the GL scheme in order to investigate naïve driving behaviour and comprehensibility of the GL scheme (self-explanatory design).

2.1.3 Vehicle emissions values

Eligibility for the GL scheme is determined by vehicle emissions category (VED band). Only those vehicles below a certain CO₂ g/km emission threshold will be allowed to make use of the designated lane. Therefore, participants were instructed that the driven vehicle for the simulator study was at one of two levels of vehicle emissions, either:

- Low CO₂ emission vehicle (VED band 'C', 111-120 g/km) or
- High CO₂ emission vehicle (VED band 'D', 121-130 g/km)

Before the drive, participants were informed as to the CO₂ emission values of their vehicle. The break-down of participant groups is shown in Figure 3.

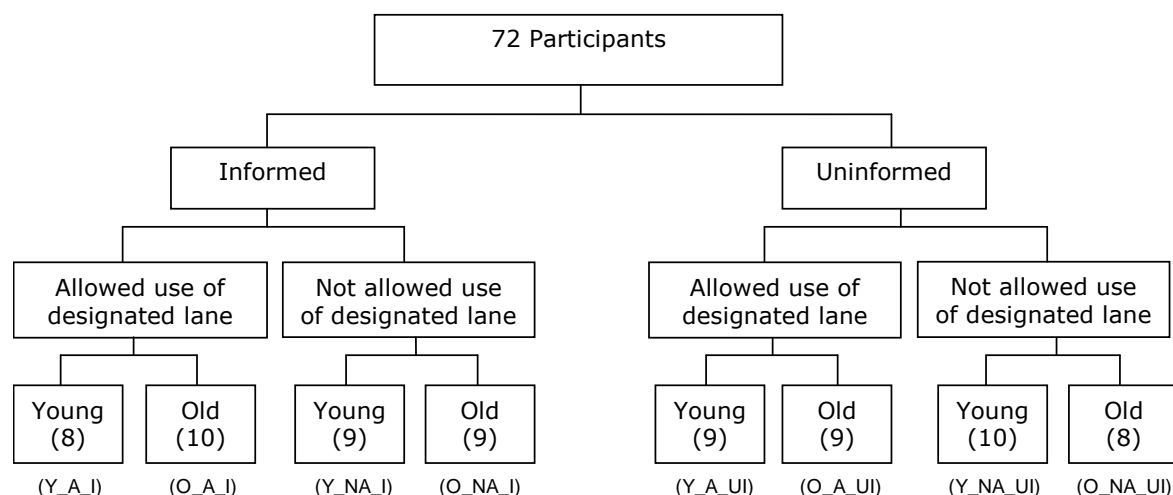


Figure 3: Participant breakdown. Acronyms in brackets identify each unique group (e.g., 'Y_A_I' refers to the group consisting of Younger, Allowed, and Informed participants)

2.2 Experimental design

The design required each participant to drive one route in the simulator for a period of around 30 minutes. This followed an initial familiarisation drive to acquaint them with the controls of the vehicle and allow them to settle into normal behaviour in the simulated environment. Each participant session lasted for an hour, and included introduction, familiarisation, test drive and debriefing.

2.3 Route design

2.3.1 General features

The route consisted of approximately 28km of a 3-lane motorway (plus hard shoulder) containing six junctions, and configured mainly as FT TJR with lead-in and lead-out sections. The road layout, signs, and lane markings in the route were based on Highways Agency documents, 'Managed Motorway Implementation Guidance – Dynamic use of the hard shoulder' and 'Managed Motorway Implementation Guidance – Through junction hard shoulder running'. These conformed to the specification outlined in the appendices to the document "605 (387) Support for the managed motorways project: Proposal for additional simulations". The green lane design was based on the design developed for the SLT scheme (see document RPF 333 'SLT Scheme Design Template'). The green lane was delineated by a double solid white line. Access and egress zones were of the dimensions and characteristics of the SLT scheme.

The motorway surroundings were generic with fields and trees. Concerning traffic on the motorway, where heavy traffic conditions are specified, each autonomous vehicle within the simulation was programmed to follow the vehicle ahead as closely as possible. Whilst this created a high density of traffic, gaps remained between vehicles into which it was possible to drive the simulator vehicle. However, this level of gap acceptance could be considered extremely unsafe.

2.3.2 Route summary

The route contained six junctions preceded by a lead-in section and concluded with a lead-out section (for a detailed diagram of the route and associated signs and signals

see Appendix A). Lane below signal 1 (LBS1) was not in use within Junction 1, but within the other five junctions, LBS1 was open for traffic. Outside of the junctions LBS1 was open in some sections, but closed in others. The aim of closing LBS1 was to increase traffic density on LBS 2 to 4. In turn, this may instigate drivers to make legitimate or illegitimate use of the designated lane. A variable speed limit (VSL) of 60mph was in place across all lanes at the start of the route. The speed limit in the designated lane then increased to 70mph, to enable an evaluation as to whether more drivers would use the designated lane when swifter progress is possible. As drivers progress down the route, traffic conditions became heavier and speeds in the normal running lanes dropped, providing a greater advantage to drivers using the designated lane. Participants were asked to leave the motorway at Junction 3 and rejoin the motorway from the same junction. This allowed for an evaluation of driving behaviour upon exiting and entering the motorway from and to the designated lane. Table 1 shows the configuration of the route and is described in further detail below.

Table 1: FT TJR plus designated lane Route

Description	Length	Configuration				
		TJR	LBS1 <i>in section</i>	LBS1 <i>within jct</i>	Speed limit LBS1,2&3	Speed limit green lane
Lead-in	4km	N/A	Not in use	N/A	blank	blank
Junction 1-2	4km	FT TJR	Closed	Open	60	60
Junction 2-3	4km	FT TJR	Closed	Open	60	70
Junction 3-4	4km	FT TJR	Open	Open	60	70
Junction 4-5	4km	FT TJR	Open	Open	40	60
Junction 5-6	4km	FT TJR	Closed	Open	40	40
Lead out	4km	N/A	Not in use	N/A	blank	blank

2.4 Participant instructions

Participants were delivered standard instructions before driving the simulator. They were told to 'drive as you normally do' and that their 'driving is not being judged'. They were also told that they 'should not treat the simulator like a computer game'. Participants were instructed that they are 'late for an urgent meeting and must hurry to get there in time'. This was to test participants' willingness to contravene the lane segregation in order to make most rapid progress along the route.

'Informed participants' received detailed information regarding the 'green lane' scheme including an overview of the physical layout, signage and procedures.

'Non-informed participants' were not given any information about the scheme prior to the trial drive.

All participants were informed of the type of vehicle they are driving prior to the trial drive.

2.5 Measures

Analysis of behaviour focused on the following areas:

- Lane choice

- Speed choice
- Location(s) at which drivers chose to use the 'green' lane, and characteristics of those locations
- Level of contravention
- Behaviour at junctions
 - Position at which drivers moved to auxiliary lane for exit
 - Position at which drivers rejoined motorway at merge
 - Response to designated 'green' lane signs/lane markings
 - Use of FT TJR

Participants were asked to fill out a brief questionnaire (see Appendix A). In addition to the standard background information, this included questions designed to elicit participants' views on:

- Clarity/legibility of the signs designating a green lane
- Understanding of the green lane operation
- Confidence in using the green lane (if applicable)
- Exiting/entering the motorway with a green lane in operation

Analysis focused on these issues and differences between the younger and older participants.

3 Results

3.1 Participant sample

72 participants were recruited for the trial. Participants were split into matched groups for comparison. The 72 participants were divided equally as informed and uninformed (36 in each). Within this 36 participants were split into two groups of allowed and two groups in the not allowed sections with 18 in each. These were then divided by age and gender. Due to difficulties at the recruitment stage, group sizes were similar but not equal (each contained either 8, 9 or 10 participants (see Table 2)).

Table 2: Overview of experimental groups

Group							
Younger	Younger	Younger	Younger	Older	Older	Older	Older
Allowed	Not allowed	Not allowed	Allowed	Allowed	Not allowed	Not allowed	Allowed
Informed	Informed	Uninformed	Uninformed	Informed	Informed	Uninformed	Uninformed
(Y_A_I) n=8	(Y_NA_I) n=9	(Y_NA_UI) n=9	(Y_A_UI) n=10	(O_A_I) n=10	(O_NA_I) n=9	(O_NA_UI) n=9	(O_A_UI) n=8

There was a large difference in the mean number of years since licence acquisition and the mean estimate of annual miles driven across the age groups. As can be seen in Table 3, drivers in the older categories held their licence for around 25 years more than young drivers. Younger drivers reported driving over 5000 miles per year more than the older drivers.

Table 3: Mean years held licence and mileage last year per age category

Age category	Years held licence		Mileage last year	
	Mean	SD	Mean	SD
Younger	11.71	7.58	13389	8600
Older	36.97	7.20	8014	3868

3.1.1 Confidence in day-to-day driving and driving on motorways

To ensure our participants were of a similar level of confidence when driving, participants were asked to rate their level of confidence when driving day-to-day and driving on motorways (1 = not confident at all; 10 = very confident).

For day-to-day driving, the mean confidence for older and younger drivers were almost identical ($M=8.17$; $SD=1.8$ and $M=8.22$; $SD=.90$ respectively). A Mann-Whitney U test was performed on the data and this revealed no significant difference between groups ($z=-.130$, $p = .90$).

Similar results were reported for mean confidence during motorway driving, with mean confidence for older and younger drivers again almost identical ($M=7.92$; $SD=1.30$, and $M= 7.77$; $SD=1.35$ respectively). A Mann-Whitney U test was performed on the data and this revealed no significant difference between groups ($z=-.52$, $p = .60$).

These results indicate that the drivers have similar feelings in their levels of confidence both day-to-day and motorway driving, with no difference between age category.

3.2 Driving behaviour

The figures below show the mean lane positions across participants in each of the eight experimental subgroups in the various route sections. Each figure shows the mean lane position of the simulator vehicle through the section. The participants' movement along the route is represented by movement of the trace up the graph in the Y-axis.

Dotted lines that span both graphs indicate where signs and events of interest were encountered. For each section, a brief interpretation of participant behaviour is given. Although the graphs cannot provide detailed information about individual behaviour, they are instructive in relation to the general behaviour of participants within each group.

For the analysis, the lead in and junctions were split up into sections. Figure 4 shows the three sections in the lead in that were used to analyse the data. Section 1 refers to the start of the route up to the start of the green lane access zone (1/2 Mile sign). Section 2 runs from the end of section 1 up to the 'Green Lane only' sign. Finally, section 3 refers to the end of the access zone and start of the double white solid line markings of the green lane. With respect to the junctions, each junction was split into the three sections as illustrated in Figure 5.

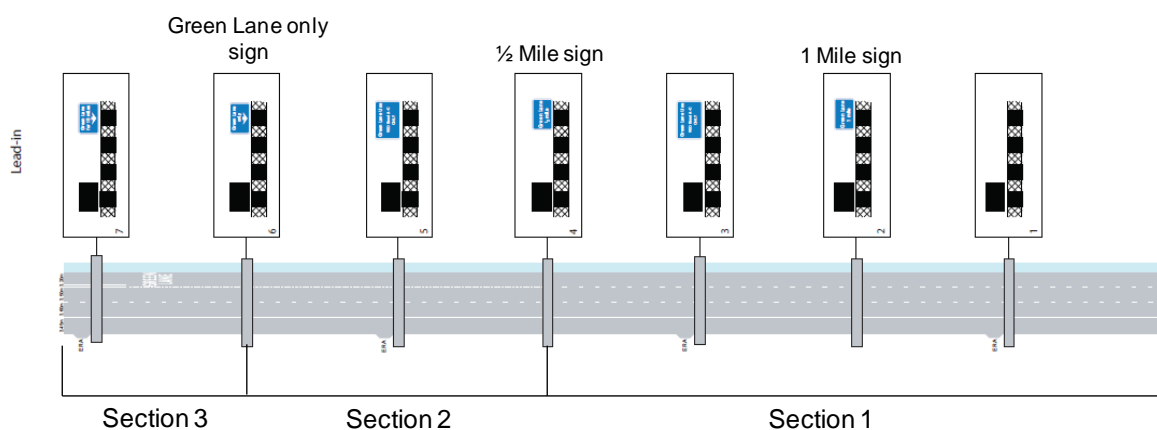


Figure 4: Section division of lead in

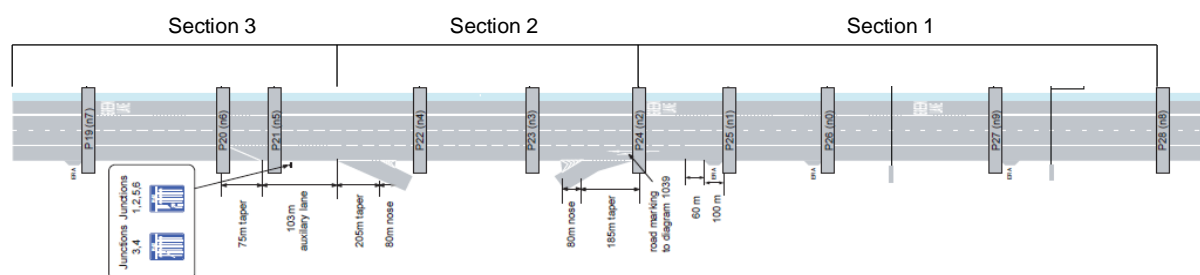


Figure 5: Diagram illustrating the 3 sections used for the analysis in the lead in (top) and each of the junctions (bottom)

3.2.1 Lead in

The lead in was a 4 km section with no speed limits displayed, and the hard shoulder closed to traffic (i.e. a standard 3-lane motorway, but with a blank signal over the hard shoulder). Light traffic was present comprising a mixture of cars, lorries and buses travelling at 40-60mph. These vehicles were included to ensure that participants obeyed

the instruction that they are late for an urgent meeting. Towards the end of this section the participant encountered the designated lane scheme access zone and viewed the verge/gantry signs and the lane markings of the green lane scheme. Traffic conditions remained light such that the participants were able to travel in whichever lane they felt was appropriate. The gantry signals remained blank.

Overview lane positioning within lead in section

An overview of lane positioning for all groups in the different sections is presented in Figure 6. Reflecting participants' instructions that they were late for an urgent meeting, it can be seen that allowed and not allowed groups initially exercised very similar lane choice strategies, moving from LBS2 into LBS3 and 4, before splitting on approach to the GL access zone, with not allowed drivers moving back towards LBS2 and LBS3, and allowed drivers selecting the GL. It can further be seen that younger drivers were more inclined to use LBS4 than older drivers.

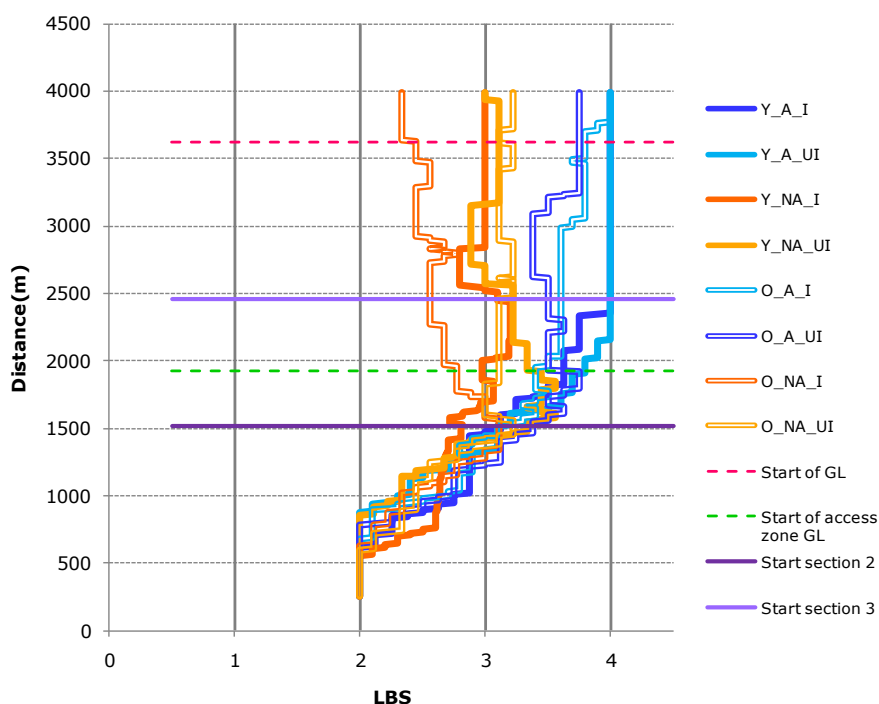


Figure 6: Mean lane position for each driver group within Lead-in, all sections

Section 1 – Speed choice

Contrary to expectations and previous findings, younger participants drove at slightly slower speeds (mean=37.9mph, SD=11.3) than older participants (mean=39.3mph, SD=8.8) although the difference was small and failed to reach statistical significance ($t(70) = 4.84, p > .568$). Note that the low speeds can be attributed to the fact that this was the start of the drive where participants accelerated from standstill to normal motorway speeds.

Section 2 – Approach to green lane and access zone

New road signs might have the effect of drivers slowing down possibly in an attempt to allow them more time to read and comprehend the signs (e.g., Diels et al., 2008). When comparing participants' speed at different points on approach to the green lane scheme signs (see Table 4), no such effect was observed in this study. Participants did not slow

down in response to the new signs and kept a consistent speed on approach to the start of the green lane in section 2.

Table 4: Speed in response to Green lane advance warning signs with start of green lane (section 3)

Sign	Speed 200m before sign (mph)		Speed 50m before sign (mph)		Speed at sign (mph)	
	Mean	SD	Mean	SD	Mean	SD
Green lane 1 mile ahead	52.1	6.8	55.3	6.7	55.1	7.5
Green lane ½ mile ahead/access zone start	57.0	6.9	59.0	7.9	59.0	7.8
Green lane start	61.2	10.0	62.1	10.5	62.6	10.3

Section 2 – Use of access zone

For each of the participant groups, Table 5 shows the proportion of participants that used the access zone in section 2, as well as the percentage time spent in the access zone by those using the zone. Since this section represents the very first experience with the new scheme, it is of interest to note that compared to those who were not allowed to use the green lane, a large proportion of allowed participants made use of the green lane from the very beginning. The results also indicate that those participants who were not allowed to use the green lane were less inclined to use the green lane access zone. It can also be noted in the table below that participants in the not allowed group but were informed of the workings of the green lane showed a lower percentage use rate compared to that of the uninformed not allowed participants. This suggests that participants in the not allowed/uninformed group initially were slower to respond to the imposition of the lane restrictions. However, these results suggest that even upon first encounter, participants largely behaved as intended.

Table 5: Proportion of participants in each group and percentage of total time that participants drove on the green lane access zone

Participant groups			Proportion	% use
Younger	Informed	Allowed	8/8	86%
		Not Allowed	3/9	52%
	Uninformed	Allowed	10/10	97%
		Not Allowed	3/9	78%
Older	Informed	Allowed	7/10	98%
		Not Allowed	2/9	11%
	Uninformed	Allowed	6/8	90%
		Not Allowed	4/9	89%
Total			43/72	75%

Section 3 – Start of green lane

Participants did not display any significant differences in speed when compared by informed/uninformed and allowed/not allowed categories in the earlier advance warnings signs. However, differences in speeds began to appear when approaching the “green lane only” signs between the allowed and not allowed groups. Figure 7 illustrates these differences and shows that the mean speed (mph) for participants 200 metres before the green lane signs was 67.5 (SD=8.8) for the allowed group and 54.9 (SD=6.7) for the not allowed group, a difference of 12.6 mph ($p < .05$). Approaching the 50 metres sign produced mean speeds of 68.6 (SD=8.8) mph for the allowed group and 55.6 (SD = 7.6) mph for the not allowed group ($p < .01$). Lastly the means for both groups were compared at the start of green lane ('Speed before 0m of the green lane' in Figure 7). Participants in the allowed group again drove significantly faster than the not allowed group ($M=69.1$; $SD=8.5$ and $M=56.1$; $SD=7.6$), ($p < 0.01$). The differences in speed between these groups indicate the higher speeds that were attainable by use of the green lane.

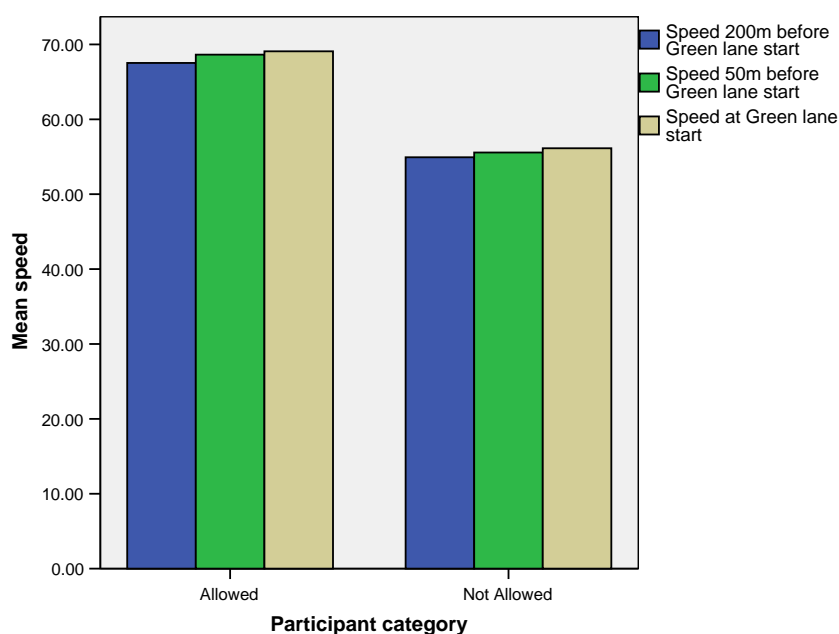


Figure 7: Mean speed (mph) of participants on approach to the start of the green lane

Table 6 displays the proportion of use of the green lane in section 3 by each participant group. 32 (89%) of participants in the allowed category were found to use the green lane in section 3 of the lead in. It can further be seen that younger participants were more likely to use the green lane than older participants. 100% of the young and allowed participants used the green lane in section 3 irrespective of whether or not they were informed as to the workings of the green lane, suggestive of the scheme being clear to participants.

Table 6: Use of green lane in lead in section 3 for each participant group

Participant group	Proportion green lane users (%)	Participant group	Proportion green lane users (%)
Y_A_I	8/8 (100%)	O_A_I	8/9 (89%)
Y_A_UI	10/10 (100%)	O_A_UI	6/8 (75%)
Y_NA_I	0/8 (0%)	O_NA_I	1/9 (11%)
Y_NA_UI	1/9 (11%)	O_NA_UI	1/9 (11%)

The level of contravention in this section was found to be low. In the younger group, only one uninformed participant illegitimately drove in the green lane; in the older group there was one informed and one uninformed participants that incorrectly made use of the green lane.

3.2.2 Junction 1

Figure 8 shows the mean lane position per participant group in Junction 1. It clearly illustrates the difference in lane use between allowed and not allowed participant groups with the allowed group mainly driving in the green lane. Again, it can be seen that younger drivers were more inclined to use the green lane than older drivers.

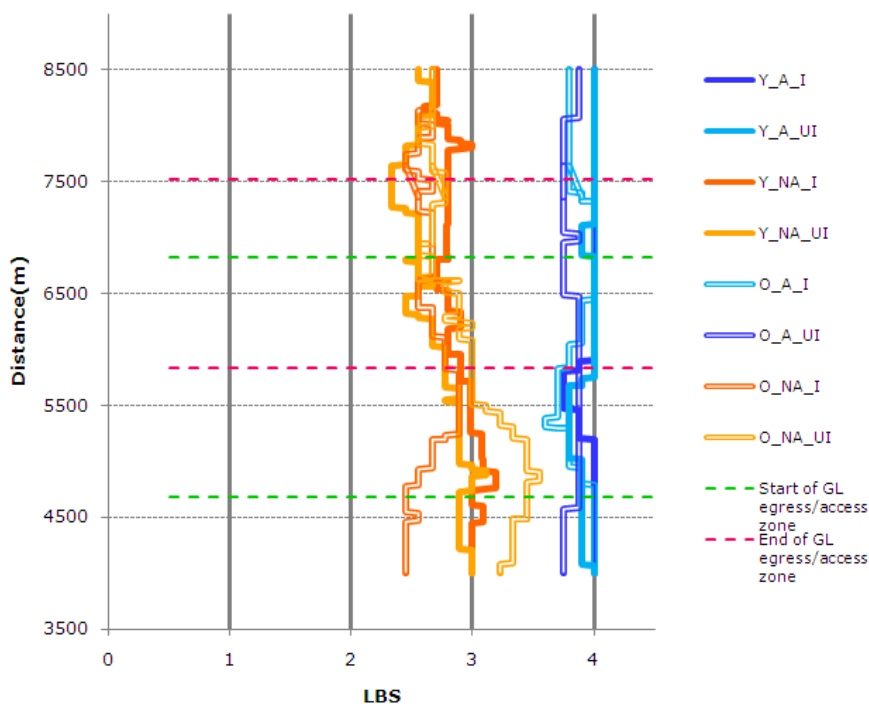


Figure 8: Mean lane position for each participant group (Junction 1)

It was further observed that drivers who began in the GL continued to use the green lane throughout the junction (see Figure 8). These drivers were exclusively within the allowed groups. Amongst the not allowed groups, there was a greater variation of lane positioning (as we might expect given they were free to choose from either LBS2 or LBS3).

Table 7 shows the proportion of participants as well as the percentage of time participants used the green lane per group. It can be seen that a considerable proportion

of participants that were not allowed to use the green lane nevertheless did so, even when they were informed as to the workings of the scheme. This is a surprisingly high level of contravention although it should be noted that those who illegally drove in the green lane did so for only a small proportion of the time, and this was especially true for the younger participants.

Table 7: Proportion of participants in each group and percentage of total time that participants drove on the green lane

Participant groups			Proportion	% use
Younger	Informed	Allowed	8/8	99%
		Not Allowed	3/9	4%
	Uninformed	Allowed	10/10	96%
		Not Allowed	3/9	2%
Older	Informed	Allowed	10/10	89%
		Not Allowed	2/9	11%
	Uninformed	Allowed	7/8	94%
		Not Allowed	5/9	45%
Total			48/72	55%

3.2.3 Junction 2

Figure 9 displays the mean lane position for all groups of participants throughout Junction 2. A clear distinction in lane selection can be seen between the allowed and not allowed groups. Allowed drivers were mostly in the GL and LBS3. Not allowed drivers were mostly in LBS2 and LBS3. This shows a clear distinction in lane choice between drivers who were allowed and not allowed to use the GL.

With the exception of one older uninformed participant, all allowed participants used the green lane for the majority of Junction 2. Within the allowed group, Younger drivers tended to use the green lane more (97% use) than Older drivers (86%).

For the group that was not allowed to make use of the green lane, 7 out of 18 Older participants (5 of which were in the uninformed group) illegitimately drove in the GL. In the Younger participant group, 6 out of 18 (3 informed, 3 uninformed) participants illegitimately made use of the GL. Although these are relatively high proportions, it should be noted that the percentage of time spent in the GL was low, 12% and 1% for the Older and Younger group, respectively.

In section 3 of Junction 2, the speed limit in the green lane increased from 60mph to the national speed limit, whereas the speed limit remained at 60mph in LBS 2 and 3. This allowed for the observation whether certain participant groups moved to the green lane as it allowed for swifter progress.

For the allowed group, the results showed no increase in green lane use when compared to preceding sections with all but one participant already in the green lane. For the group that was not allowed to use the green lane, the increase in speed limit on the green lane did not lead to sudden increase of illegitimate use of the green lane. In fact, no participants that drove in the green lane in section 3 were not in the green lane already. Thus, it can be concluded that the higher speed limits (national speed limit) in the green lane did not lead to an increase in its use by either allowed or not allowed participants despite traffic in LBS2 and 3 travelling at lower speeds of 50-60mph.

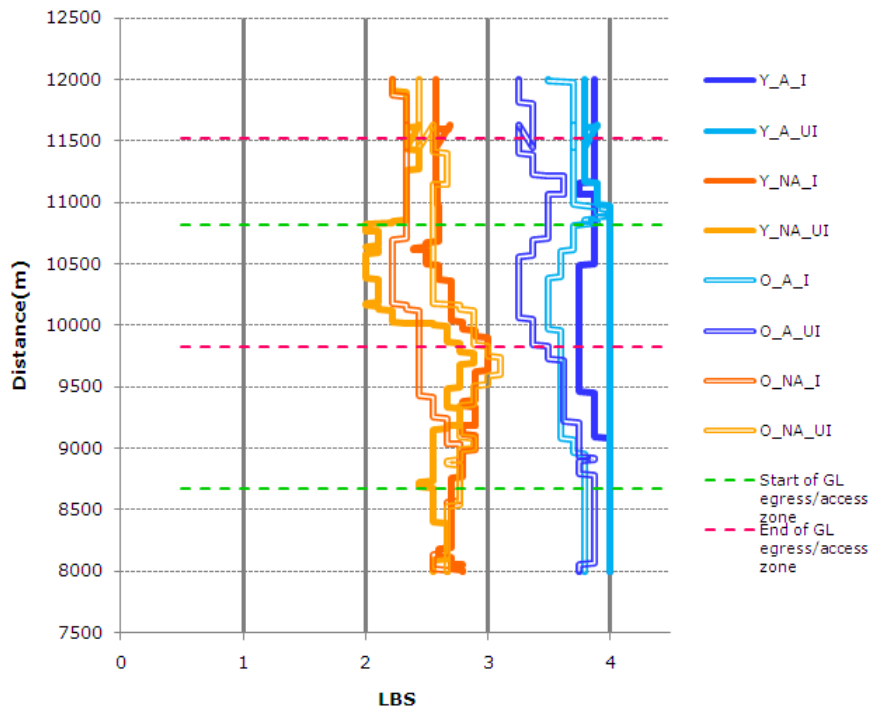


Figure 9: Mean lane position for each driver group within junction 2

3.2.4 Junction 3

In Junction 3, participants were required to exit and then re-enter the motorway. Upon approach to Junction 3, LBS1 was closed to traffic with traffic travelling at 60mph in LBS2 and 3. Continuing from Junction 2, 28 out of 36 allowed participants approached Junction 3 from the green lane. Of the 8 participants in the allowed group who did not use the green lane, 6 were older participants. Note that at this stage, none of the not allowed participants drove in the green lane and used LBS 2 and 3 instead.

Figure 10 describes how all traffic began to move towards LBS2, with participants in the green lane leaving the lane before the start of the egress zone, and hence, illegitimately crossing the double white lines. This is illustrated in more detail in Figure 11 (left panel). Seven participants, of which five were from the older group, left the green lane before the start of the egress zone. The remaining 21 participants correctly left the green lane upon entering the egress zone.

Figure 11 (right) shows the position of green lane users' first entrance into LBS1. It can be seen that most green lane users first entered LBS1 within 100 metres of the start of the off-slip. Although green lane users had to cross an additional lane to reach LBS1 (see Figure 10), comparison with non-green lane users shows that the position of first entrance into LBS1 was very similar (Figure 12).

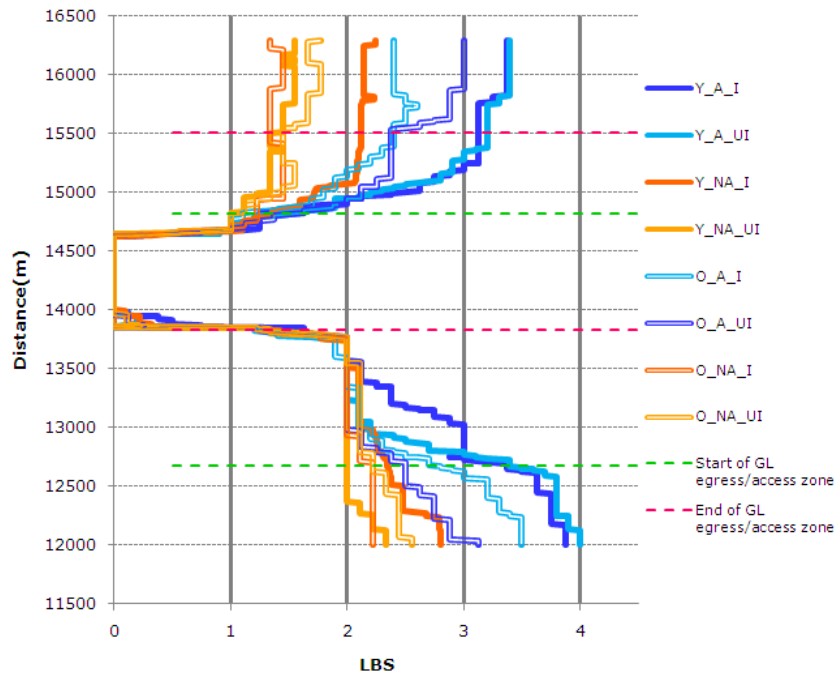


Figure 10: Mean lane position for each driver group within junction 3

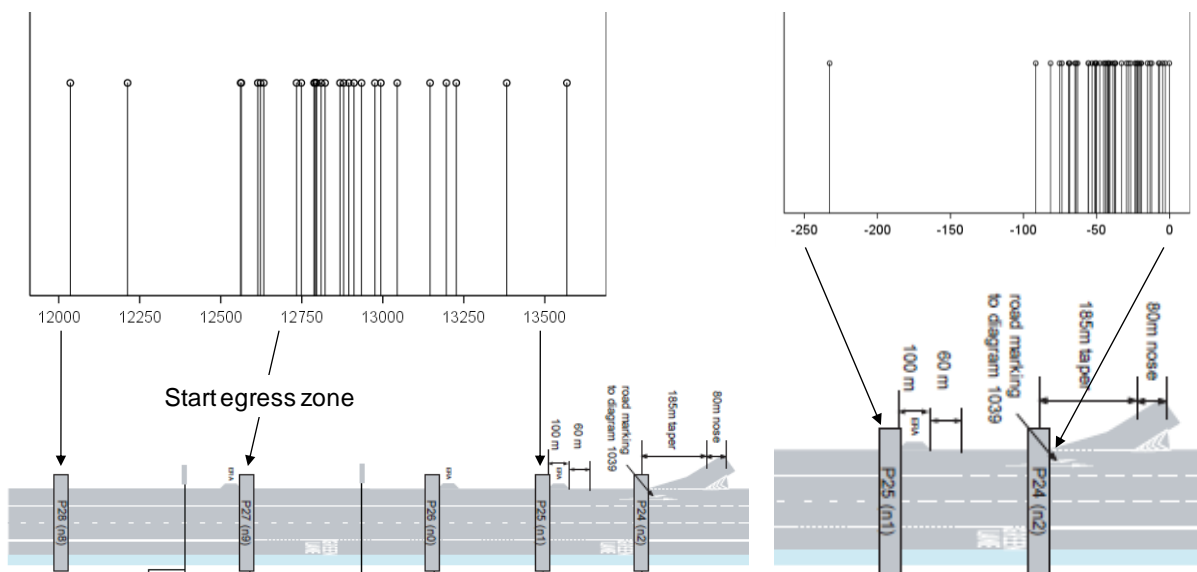


Figure 11: Position of last exit green lane (left) and first entrance LBS1 (right) to leave the motorway at Junction 3 for green lane users

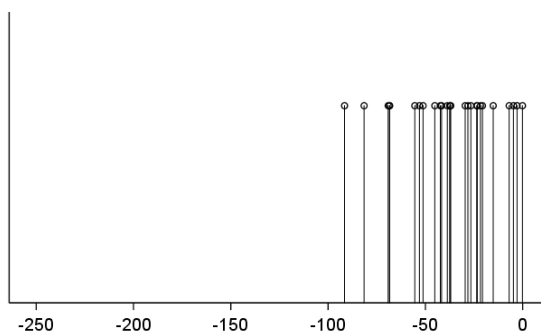


Figure 12: Position of first entrance LBS1 for non-green lane users

As shown in Figure 10, allowed participants tended to rejoin the green lane upon re-entering the motorway. Younger allowed participants tended to arrive in the green lane sooner than older allowed participants.

Ideally, all allowed drivers would have entered the green lane before the end of the green lane access zone. However, the mean lane positions of the four allowed groups suggest that this was not the case. A significant proportion of drivers did not re-enter the GL after rejoining the main carriageway. It is however not clear whether this was because there was not enough time to re-enter the green lane before the end of the access zone or due to traffic.

3.2.5 Junction 4

In Junction 4, LBS1 was open to traffic, and a 60mph speed limit was displayed on LBS1 to 3 in sections 1 and 2, whilst the national speed limit roundels were displayed above the green lane.

In section 3 of Junction 4, traffic in LBS1 and 2 slowed to 40mph. Traffic in LBS3 and the designated lane was moving at 50mph and 60mph, respectively. The relative speed differences allowed observation of whether drivers moved to the green lane under conditions where the speed limit in the green lane was higher than that in other lanes and swifter progress was possible.

Despite the speed differential between the normal running lanes and the green lane, the level of contravention was very low. Of those participants that were not allowed to use the green lane, only one older and one younger participant made use of the green lane and their percentage use was very low (5 and 10%, respectively).

3.2.6 Junction 5

As with section 3 in Junction 4, in section 1 of Junction 5, traffic was slow moving, whereas progress was swifter in the green lane. Speed limits of 40mph were displayed over LBS1, 2 and 3, and 60mph over the green lane. Despite the now apparent advantage of the green lane, not allowed participants refrained from illegal use of the green lane. The only exceptions were two (one informed and one uninformed) older participants who started to use the green lane in section 1 of Junction 5 for a considerable time (27% and 61% respectively). The uninformed older participant remained in the green lane throughout section 2.

In the last section of Junction 5, LBS1 and 2 were closed due to an incident, forcing traffic into LBS3, with a corresponding increase in traffic density. Gantries displayed red crosses over LBS1 and 2, and speed limits of 40mph for LBS 3 and the designated lane. Traffic in LBS3 became very slow moving with heavy traffic (speed of 20mph). Traffic in the designated lane was slow moving, but faster than in LBS3 (speed of 40mph). Despite

these adverse traffic conditions, none of the not allowed participants decided to use the green lane.

The adverse traffic situation had no bearing on the green lane use of the allowed groups. All allowed participants were already making use of the green lane for virtually 100% of the time throughout Junction 4 and 5.

3.2.7 Junction 6

In section 1 of Junction 6, LBS2 was opened to traffic again with traffic becoming less dense. LBS1 was open to traffic in section 2, whereas in section 3, all gantry roundels were blank. As a consequence of the easing of traffic, the number of allowed users and their percentage use of the green lane diminished throughout the successive sections within Junction 6, as shown in Table 8. These findings indicate that the level of green lane use is dependent on traffic density.

Table 8: Proportion of green lane users and percentage green lane use for sections 1-3 in Junction 6

	Section 1	Section 2	Section 3
Proportion green lane users	32/36	30/36	27/36
Percentage use	86%	79%	70%

3.3 Questionnaire results

E1 - Safety

Question E1 was focused on participants' experience of safety following their drive through the green lane scheme. Each question was rated on a 10-point scale ranging from 0 = Not at all safe to 10 = Very safe.

3.3.1 E1a – Driving in general

E1a concentrated on discovering how safe participants felt when driving in the scheme generally (1=not at all safe; 10=very safe). Results showed that with a mean of 7.4 (SD=1.6), overall, participants felt rather safe. Figure 13 shows the safety ratings for the informed/uninformed and allowed/not allowed groups. It can be seen that uninformed/not allowed group displayed the lowest score overall and felt the least safe. However, the differences were only slight and were not found to be statistically significant.

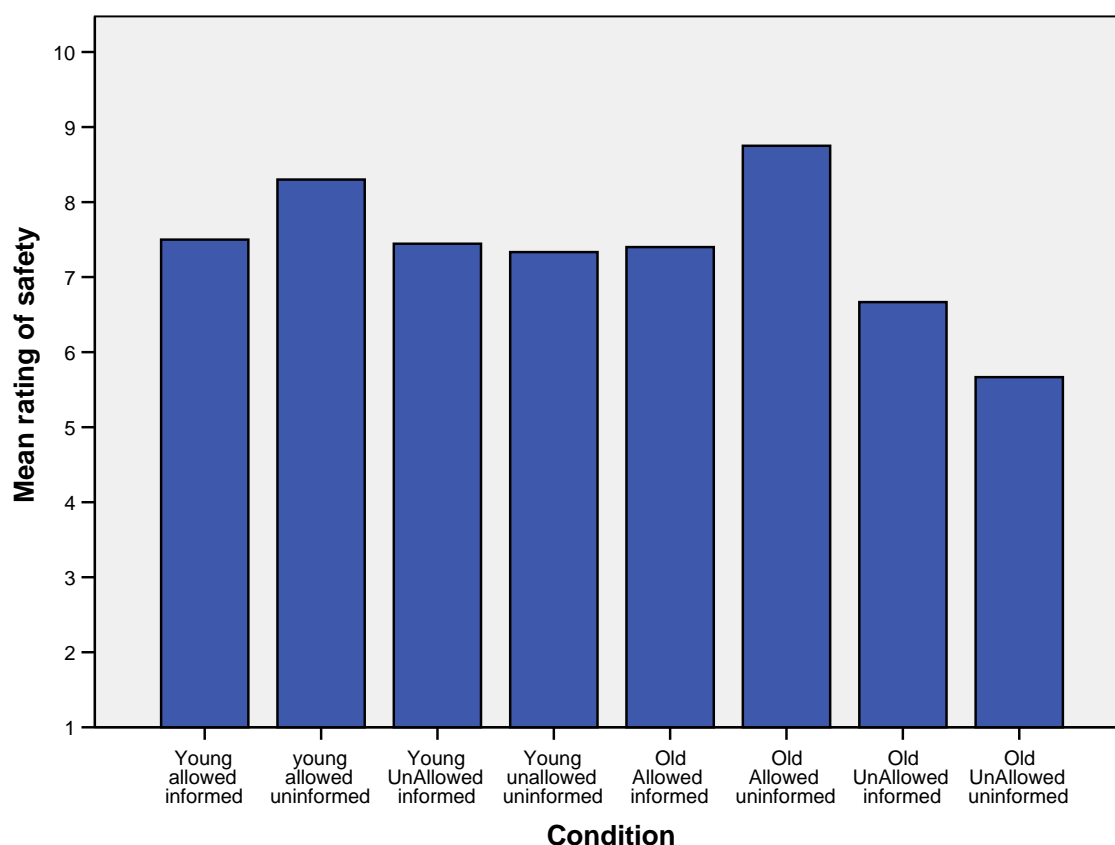


Figure 13: Bar chart showing participants' mean rating of driving safety through the green lane scheme (E1a)

3.3.2 E1b-f – Driving in LBS1-4

E1b-f was concerned with how safe participants felt when driving in LBS1 between and within junctions, and LBS2-4 (1=Not at all safe; 10=Very safe). The mean ratings for safety were calculated from participants' scores in five different questions concerning "E1b - Driving in lane 1 (former hard shoulder) between junctions, E1c – Driving in lane

1 (former hard shoulder) within junctions), E1d – Driving in lane 2, E1e – Driving in lane 3 and E1f – Driving in the green lane (lane 4)“.

For each of the questions, the differences between the different groups were very small and were not statistically significant. Figure 14 shows that participants felt most safe whilst driving in LBS2-4, whereas safety ratings were considerably lower for LBS1 in particular within junctions. A repeated measures ANOVA was performed and revealed a significant effect ($F(2.51, 100.19) = 22.11, p = 0.01$). Post-hoc comparisons indicated the safety rating for LBS1 within junctions to be significantly lower than that for LBS1 between junctions as well as LBS2-4. The safety rating when driving in LBS1 between junctions was also significantly lower than those for LBS2-4. No other differences were significant. Note, however, that not all participants had experience with either driving in LBS1 either within or between junctions, or the green lane.

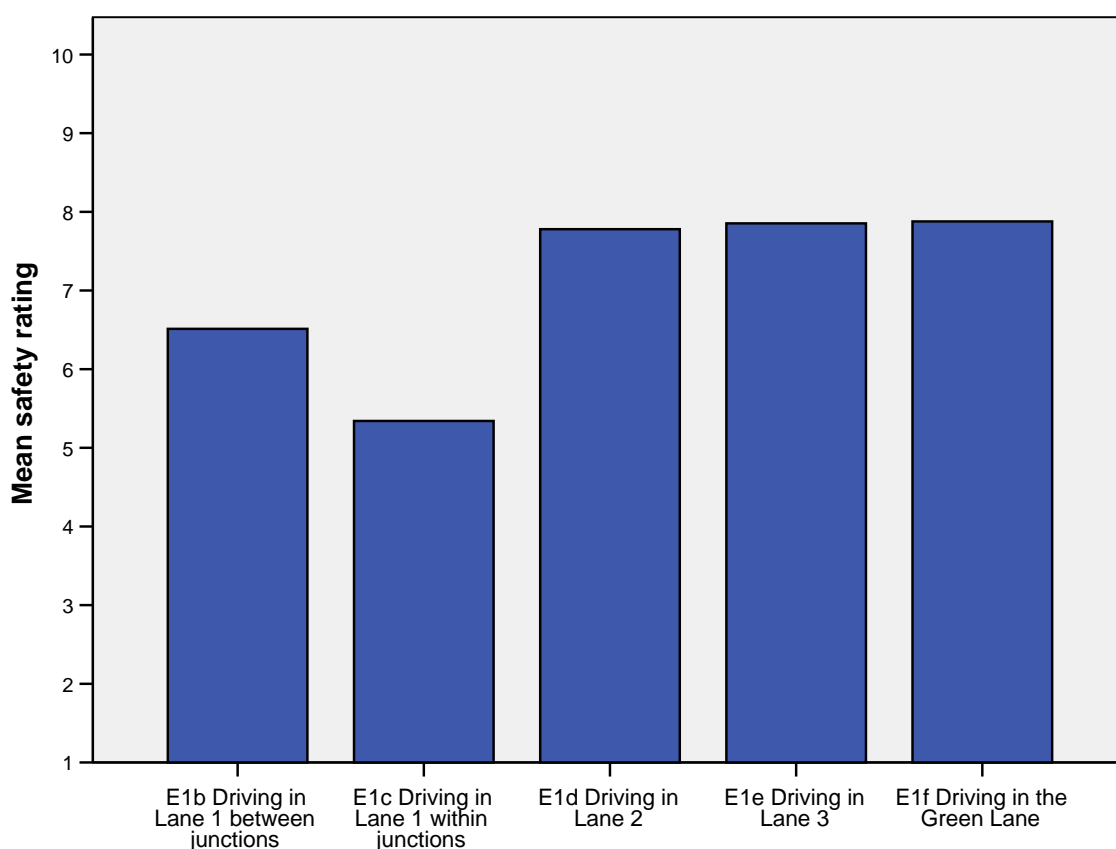


Figure 14: Participants’ mean ratings for feelings of safety in a variety of situations (E1b-f)

3.3.3 E1g-h – Leaving the motorway when the hard shoulder is open and rejoining the motorway when the hard shoulder is open

Driver’s feelings of safety when leaving and rejoining the motorway when the hard shoulder was open was examined. Participants indicated to feel less safe when *rejoining* the motorway when the hard shoulder was open (mean=6.6, SD=2.0), compared to *leaving* the motorway with the hard should open (mean=6.1, SD=2.3). This difference was found to be statistically significant ($z=-1.98, p < .05$, Wilcoxon Signed Ranks test).

3.3.4 E1i – Driving when the national speed limit applied

Participants reported to feel overall a high level of safety (Mean=8.1; SD=1.3). Relating to the groups - informed/uninformed and allowed/not allowed – participants in the allowed category recorded higher scores of safety (8.5) compared to that of the not allowed group (7.7) regardless of whether they were informed or uninformed. This indicates that participants who were allowed access to the green lane had a higher feeling of safety within the scheme when the national speed limit applied.

3.3.5 E1j-k – Leaving the motorway from the green lane and rejoining the motorway and making your way over to the green lane

For this question participants had to report how safe they felt when crossing lanes of traffic from the green lane to exit the motorway and when crossing lanes of traffic to gain access to the green lane after re-entering the motorway. Note that a small group of participants who were not allowed access to the green lane answered this question; their data was not included in the sample. Participants suggested higher feelings of safety when they rejoined the motorway and made their way over to the green lane (Mean=6.8; SD=2.2) compared to that of exiting the green lane and motorway junction (Mean=6.3; SD=2.6). However differences between the scores were not found to be statistically significant.

3.3.6 E1l – Driving when a 60mph speed limit applied

This question states how safe participants feel driving when a 60mph limit is applicable. Participants overall felt quite confident with a mean of 7.7 (SD=1.5). All participants in the different categories displayed similar scores in terms of safety, with the range from 7.9 for the allowed/uninformed group to 7.3 for the not allowed/uninformed group. Therefore those who were allowed to use the green lane but not pre-informed about its use showed the greatest feeling of safety over the other three groups when driving with a 60mph speed limit.

3.3.7 E1m – Driving under conditions in which speed limits differed for different lanes

Under conditions of differential VSL, allowed drivers reported higher ratings of safety (M=7.5; SD=1.6) compared to not allowed drivers (M=7.0; SD=1.5) when driving under variable speed limit conditions. A Mann Whitney Test confirmed this difference to be significant at the $p < 0.05$ level.

3.3.8 E1n – Approaching a junction

This question asked participants to rate their feelings of safety when approaching a junction (1=Not at all safe; Very safe). Figure 15 shows only a slight difference in safety with the informed/allowed group reporting the highest safety rating of 7.6 (SD=1.7), with the lowest rating reported by the uninformed/not allowed group (Mean=6.6; SD=1.7). Although the differences did not reach statistical significance, the results indicate that participants who are given more information about the trial show a higher safety rating than those who were not informed.

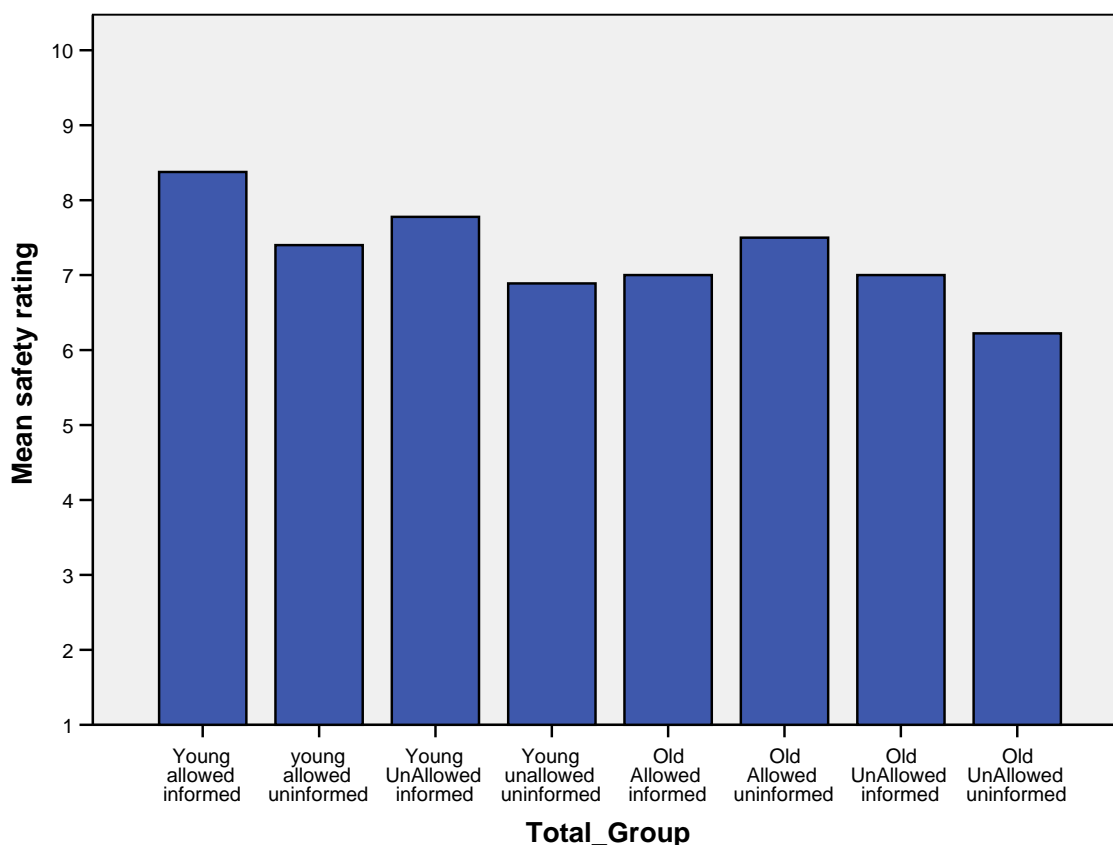


Figure 15: Participants' mean ratings for feelings of safety when approaching a junction

3.3.9 E1o – Passing an entrance slip road

Overall, participants ratings of safety for passing an entrance slip road was high, with a mean score of 7.2 (SD=1.8). Participants rating of safety was similar to that of the previous question (approaching a junction) with those who were informed and allowed scoring the highest at 7.7 (SD=1.7) and participants in the uninformed and not allowed category scoring the lowest at 6.8 (SD=1.5). Again, participants in the uninformed categories tended to feel less safe than those in the informed groups; however a Mann-Whitney test failed to find a significant difference.

3.3.10 E1p – Safety when passing, or being passed by another vehicle

During their drive participants had the opportunity to overtake other vehicles. It was also possible that they could be overtaken or undertaken within the drive. Allowed and not allowed participants may have had differing experiences in the simulated drive as allowed participants are more likely to be legitimately undertaken when they are travelling in the green lane since traffic in the normal running lanes may have made better progress.

Safety ratings are displayed below in Figure 16. The figure suggests that safety when overtaking or being overtaken was roughly similar for both groups, however when analysing the allowed group, being undertaken appears to have led to participants feeling less safe. This difference between being undertaken against the other two variables was found to be significant $F(1.68, 57.17) = 23.35, p < .001$. Thus, participants feel safer overtaking and being overtaken, but feel significantly less safe when being undertaken.

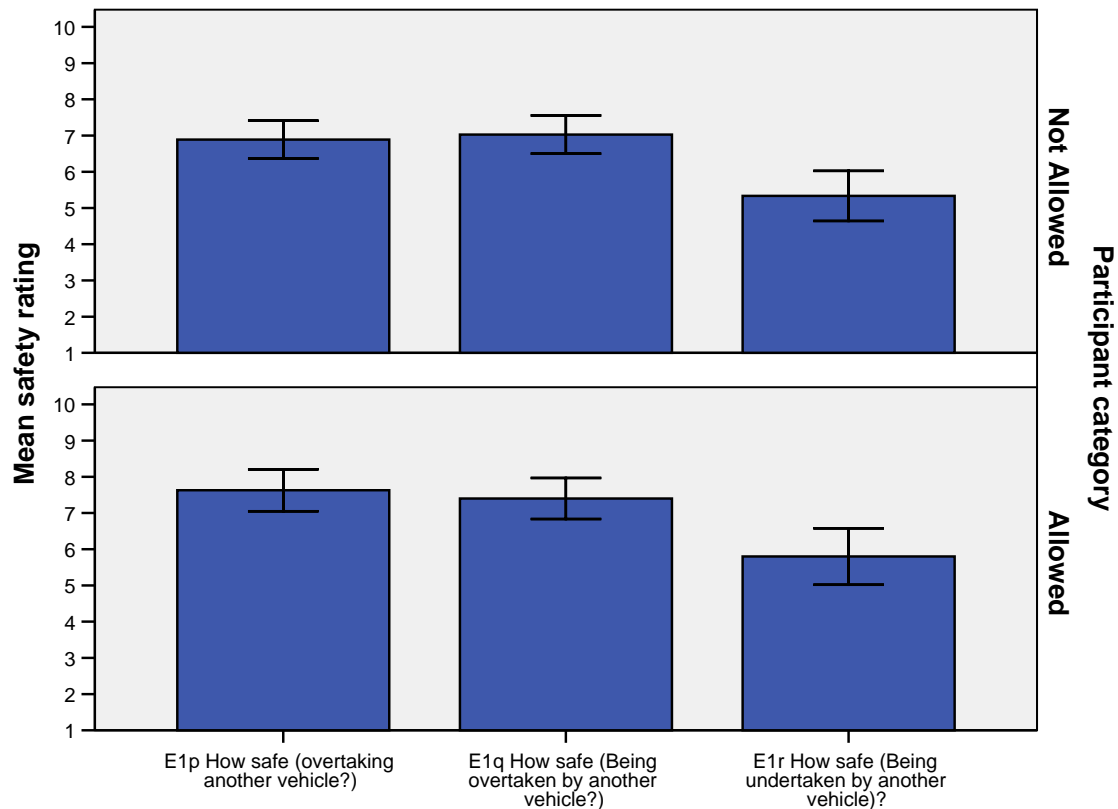


Figure 16: Mean safety ratings for allowed and not allowed participants when overtaking, being overtaken and being undertaken (E1p, q & r).

The not allowed group showed the same trend as the allowed group (Figure 16). Again, we can see participants appeared to feel less safe when being undertaken. These differences were shown to be significant ($F(2, 70) = 27.78, p < .001$). Participants suggested feeling safer in the allowed group in the undertaking question than in the not allowed group as drivers in the green lane would expect to be undertaken by other traffic. This difference was however not found to be statistically significant.

3.3.11 E1s and E1t – Entering and leaving the green lane

As in Figure 17 there was a visible difference between reported safety ratings of entering and leaving the green lane. Participants were shown to feel safer when entering the green lane than leaving. A paired sample t -test revealed this difference to be significant ($t(34) = 3.13, p < .004$). Overall, however, participants indicated to feel safe to both enter and leave the green lane.

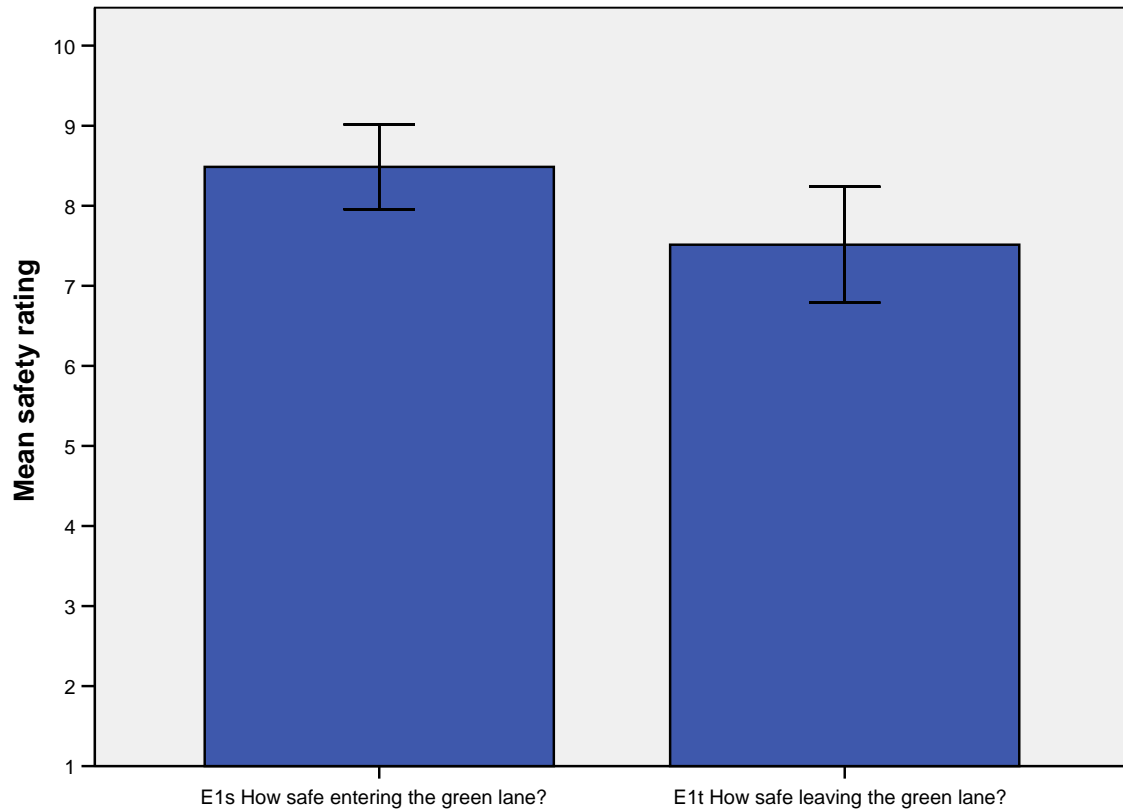


Figure 17: Mean safety entering and leaving the green lane

3.3.12 E1u-v – Driving with light and heavy traffic

Figure 18 illustrates that participants' mean ratings of safety were higher in light traffic (Mean=8.6; SD=1.0) than in heavy traffic (Mean=6.4; SD=2.0). A *t* test was performed in the data, which showed a significant difference ($t(71) = 10.36, p < .001$), showing that participants felt much safer when traffic density is lighter.

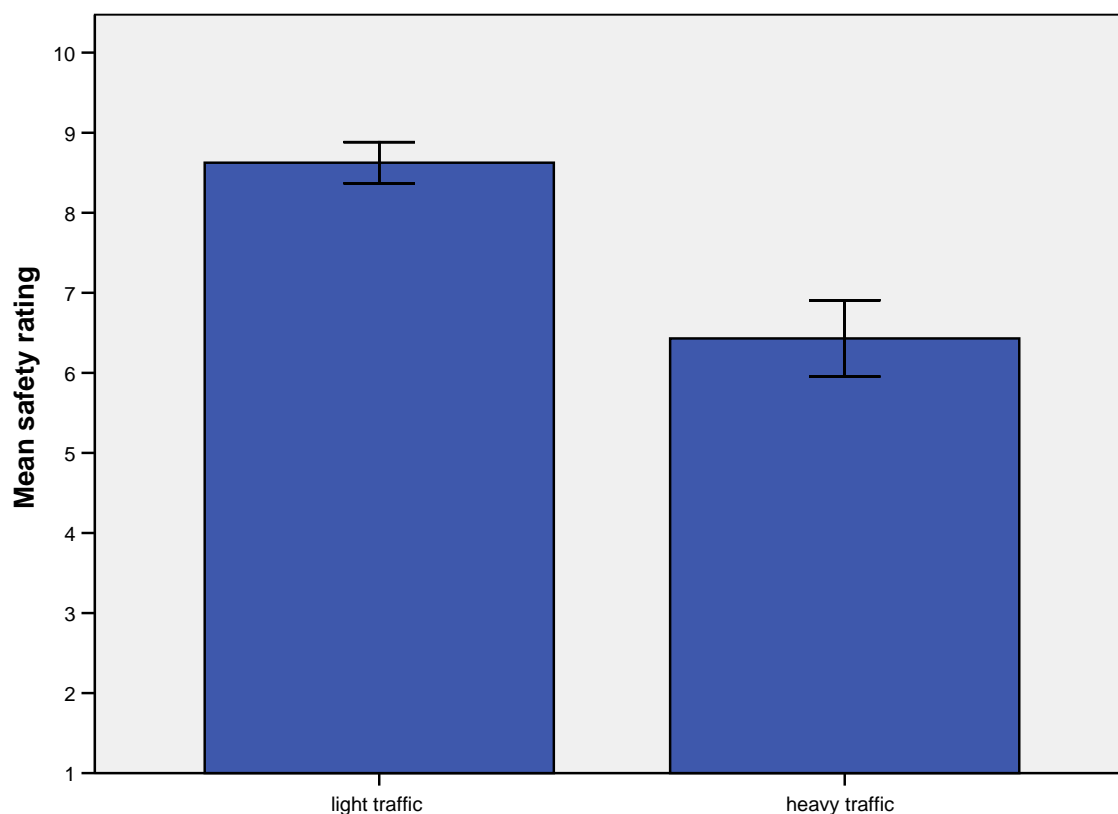


Figure 18: Mean safety scores of driving in heavy and light traffic

3.4 Participants understanding of Green lane

Participants were asked to report on their understanding of the green lane scheme. Questions were scored on a scale from 1-10.

3.4.1 F1 – Green lane commencing

This question asked participants how clear they felt the signs were that indicated a green lane was going to commence (1=Completely unclear; 10=Completely clear). Responses were compared between uninformed and informed drivers to see whether participants who had no information about the green lane understood the road layout ahead (see Figure 19). The results from an independent samples t-test showed that there was no significant difference between scores ($t(70) = 1.04, .300$). This indicates that even with informed participants reporting an overall higher rating of clarity, participants who were naïve to the green lane scheme felt the signs were sufficiently clear to understand the situation.

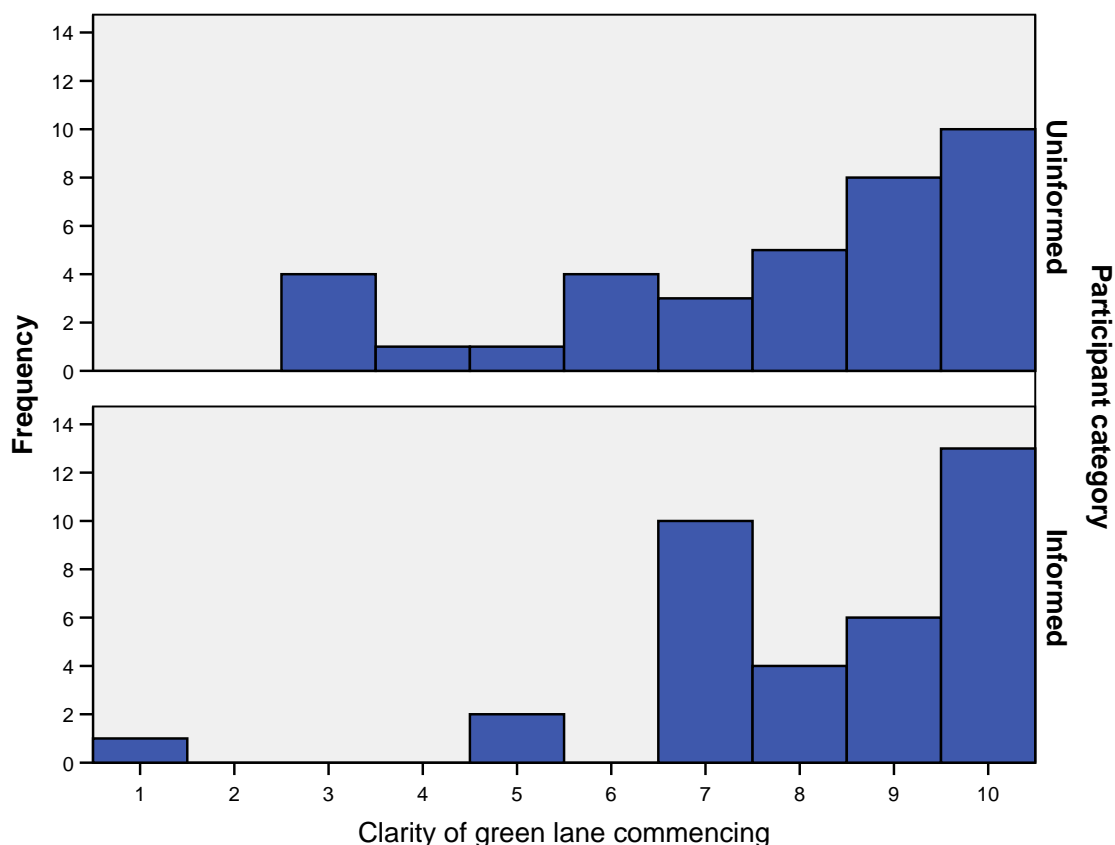


Figure 19: Frequency of responses for informed and uninformed drivers to the clarity of signs warning of the beginning of the green lane.

3.4.2 F2 – Restrictions of green lane

Question F2 asked participants whether they were aware of the restrictions that applied on approach to the green lane scheme (1=Completely unaware; 10=Completely aware). The responses as shown in Figure 20 illustrate a variance in responses between the uninformed and informed groups, but comparing means overall the uninformed category scored 6.2 (SD=3.2) with the informed group scoring a mean of 7.4 (SD= 2.5). This result suggests that the uninformed participants overall were aware of the restrictions that applied, however the range of scores as displayed in Figure 20 indicates that there was a degree of confusion within this group.

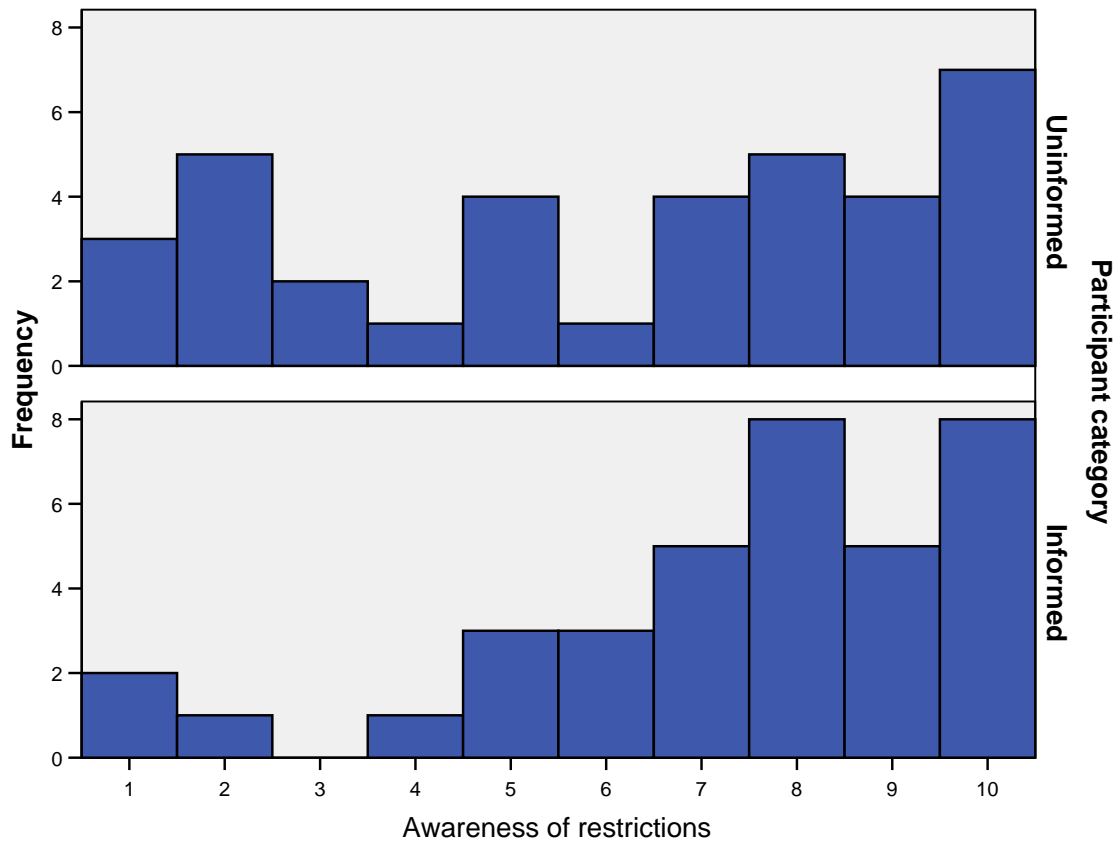


Figure 20: Frequency of responses for informed and uninformed drivers of awareness of the restrictions that applied for the green lane

3.4.3 Clarity of signs and road markings to indicate where and when to join the green lane

Participants were asked to rate how clear the road markings and signs were that indicated where and when to join the green lane (1 – completely unclear, 10 – completely clear). Although the means did not significantly differ, as indicated by the responses shown in Figure 21, a considerable proportion of both informed and uninformed participants indicated that it was not completely clear to them where and when to join the green lane.

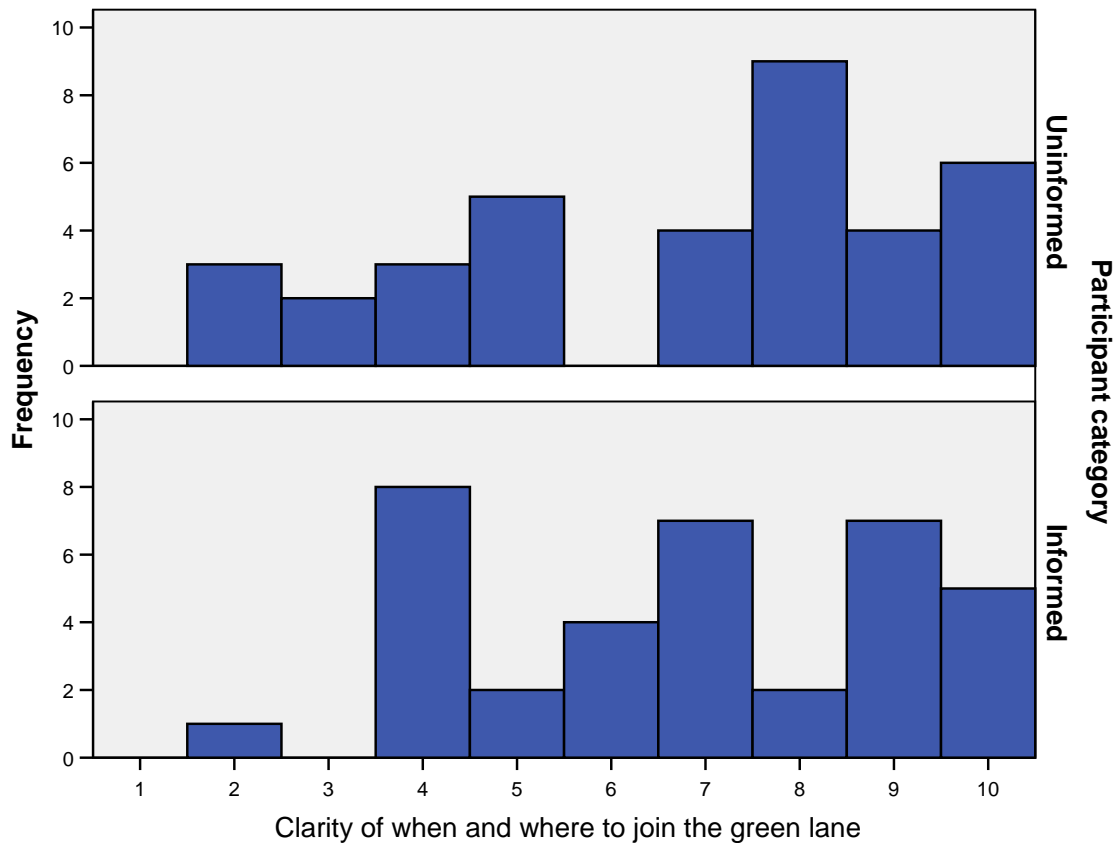


Figure 21: Frequency of responses for uninformed and informed drivers to the clarity of where and when to join the green lane.

3.4.4 F4 – Clarity of lanes permitted to drive in

Question F4 asked participants to rate how clear they felt the indication was of which lanes they were permitted to travel in (1=Completely unclear; 10=Completely clear). Participants in the informed group were shown to have higher scores of clarity over that of the uninformed group (see Figure 22). However overall means indicate that both group were quite clear on which lanes they were permitted to drive in, (Informed, $M=7.8$; $SD=2.6$, and uninformed, $M=7.3$; $SD=7.8$).

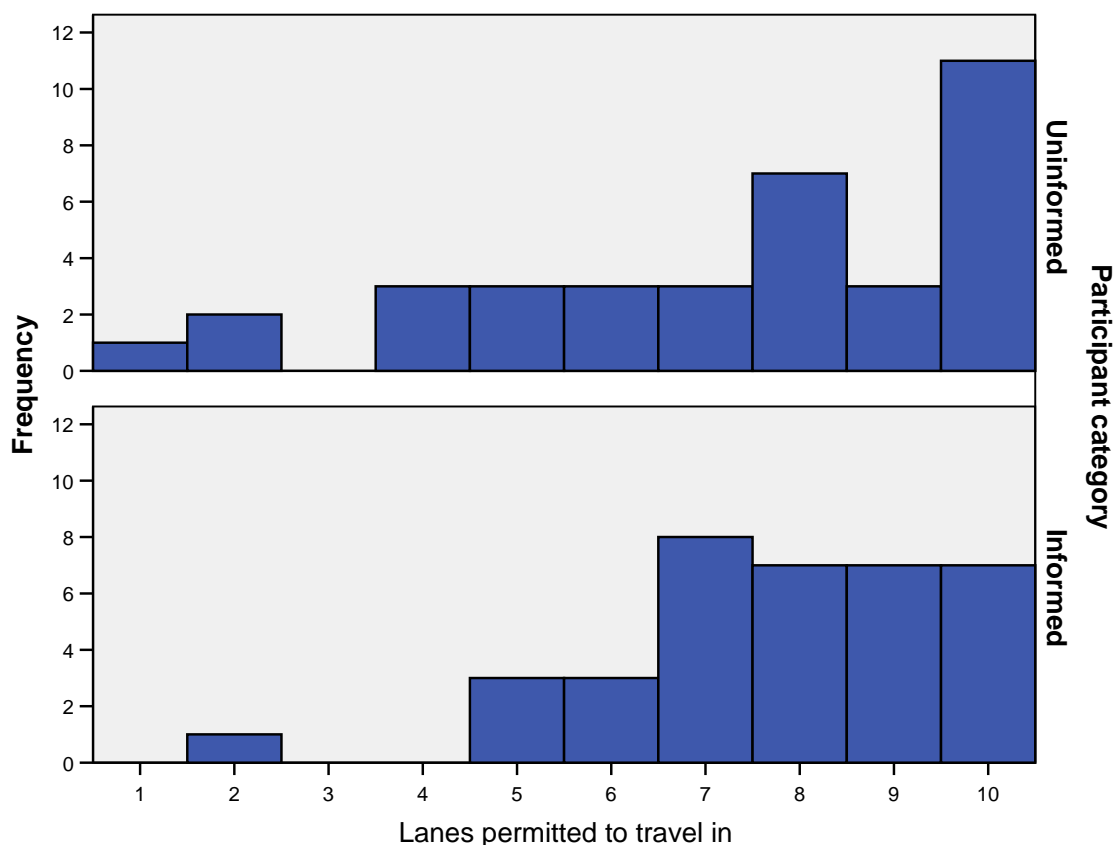


Figure 22: Frequency of responses for uninformed and informed drivers to the clarity of which lanes they were permitted to use

3.4.5 F5 – Clarity of signs and road markings clearly indicating which lanes were permitted to travel in

Question F5 was concerned with asking participants to rate the clarity of the signs and road markings that indicated permitted lanes (1=Completely unclear; 10=Completely clear). Results indicate that participants in the informed group reported higher ratings of clarity (Mean=7.7; SD=1.8) compared to that of the uninformed group (Mean=7.0; SD=2.8). Both scores however are relatively high showing that the signs and road markings were clear to participants in regards to which lanes they were permitted to use.

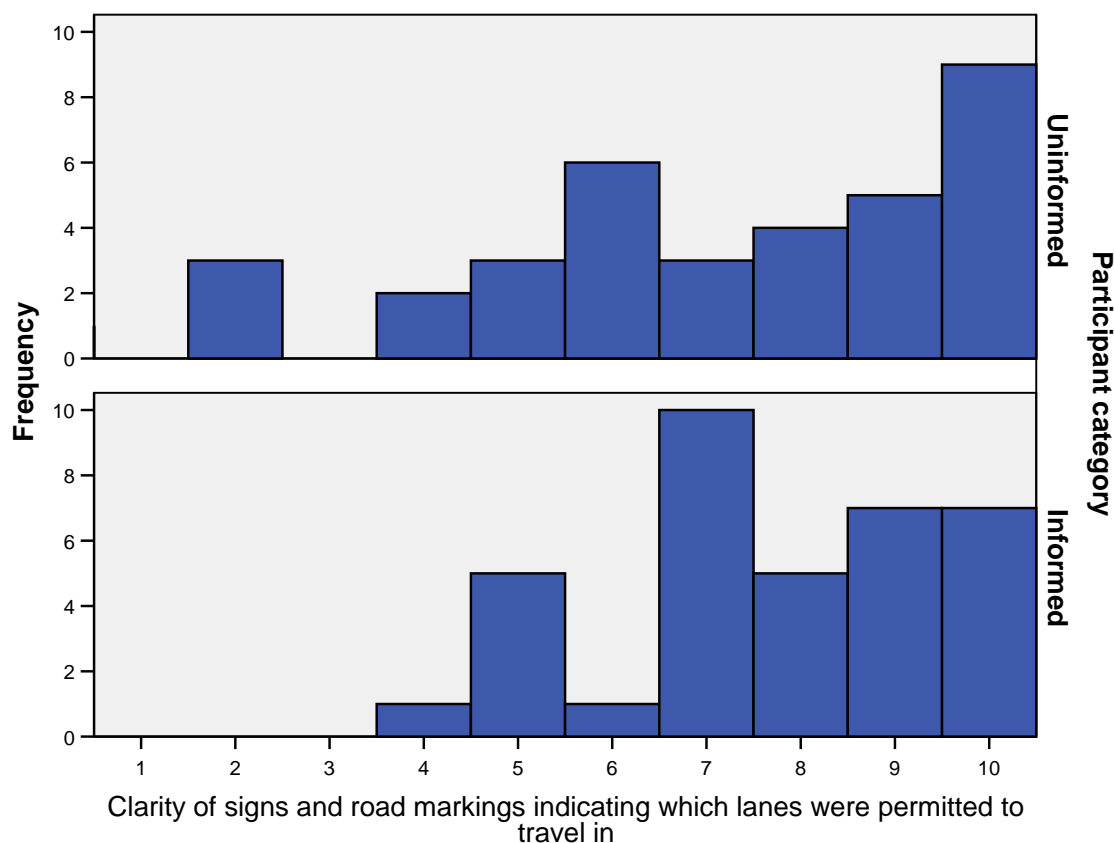


Figure 23: Frequency of responses for uninformed and informed drivers to the clarity of signs and road markings indicating the lanes in which they were permitted to drive

3.4.6 F6a – Which lanes were participants permitted to drive in?

In this question, participants selected from ABC or D (LBS1,2,3 & 4 respectively) to indicate the lanes in which they thought they were permitted to drive, given the conditions shown in the screenshot of the GL scheme. The results showed that 43 participants chose the correct lanes and 27 participants were incorrect. The table below indicates the breakdown between young/old and allowed/not allowed.

Interestingly the young and allowed participants scored the highest incorrect responses with 10 in total. There seems to have been a little confusion to whether participants in the allowed group were permitted to use the hard shoulder (LBS1) with seven stating they could only use lanes LBS2, LBS3 and LBS4.

Only one allowed participant stated that they were not permitted to use the green lane, therefore it was clear to those who were in the allowed category that they were permitted to use the green lane. Two participants in the not allowed group incorrectly stated that they could use all four lanes, with four young participants stating that they could only use the green lane. The latter observation is likely to be a misinterpretation of the question on behalf of these participants.

Table 9: Number of participants who incorrectly answered the lanes in which they were permitted to drive.

Lanes	Allowed		Not allowed		Total
	Young	Old	Young	Old	
1,2,3,4	0	0	1	1	2
2,3,4	7	3	0	0	10
2,3	0	0	2	3	5
2	0	0	0	1	1
3	0	1	0	0	1
4	3	1	4	0	8
Total	10	2	7	5	27

3.4.7 F6b – Confidence

Participants rated their level of confidence to the previous question of which lanes were they permitted to drive in. Overall participants confidence scores were very high with a mean of 8.2 (SD=1.7)

3.4.8 F7a – Permitted to travel in the green lane if LBS1 is closed?

This question asked participants to answer “yes” or “no” to whether they would be permitted to use the green lane if LBS1 was closed as a running lane. Only the participants who were in the not allowed category answers were analysed in this question as allowed participants could use the green lane regardless. Out of 36 not allowed participants only one was found to answer incorrectly to this question, therefore participants understood that even with a lane closed the green lane still remained restricted.

3.4.9 F7b – Confidence

Following the question above participants were asked to rate how confident they were of their answer of “yes” or “no” to whether they could legitimately drive in the green lane when LBS1 was closed. Participants overall were very confident of their answer, those in the allowed group demonstrated a higher degree of confidence with a mean of 8.8 (SD=1.5) as those who were in the not allowed group in comparison scored a mean of 7.5 (SD= 2.2).

3.4.10 F8a -Permitted to travel in the green lane if LBS1 and LBS2 are closed?

A similar question was asked of the participants to that of F7a, but instead asking would they travel in the green lane if two lanes were closed. All but six participants in the not allowed group answered correctly and would not choose to travel in the green lane in this circumstance.

3.4.11 F8b - Confidence

Again participants were asked of their confidence regarding the above question (Are you permitted to travel in the green lane if lanes LBS1 and LBS2 are closed?) to see if they were positive in their responses. Mirroring the result for of Question F7b, participants in the allowed group had higher confidence ratings (Mean= 8.3; SD= 2.3) than those in the not allowed group (Mean=7.1; SD=2.4).

3.4.12 F9 – Did you feel you were overloaded with the number of signs?

In this question participants were required to rate whether or not they were overloaded by the number of signs, regardless of whether or not they were driving in the green lane. The scale for this question is reverted and therefore 1 = "Not at all" with 10 = "Very much so". The result is shown in Figure 24 and shows that there were two groups. The majority of participants reported that they were not overloaded with signs (score of 5 or smaller), whereas a smaller but considerable proportion of participants indicated they felt overloaded by the number of signs.

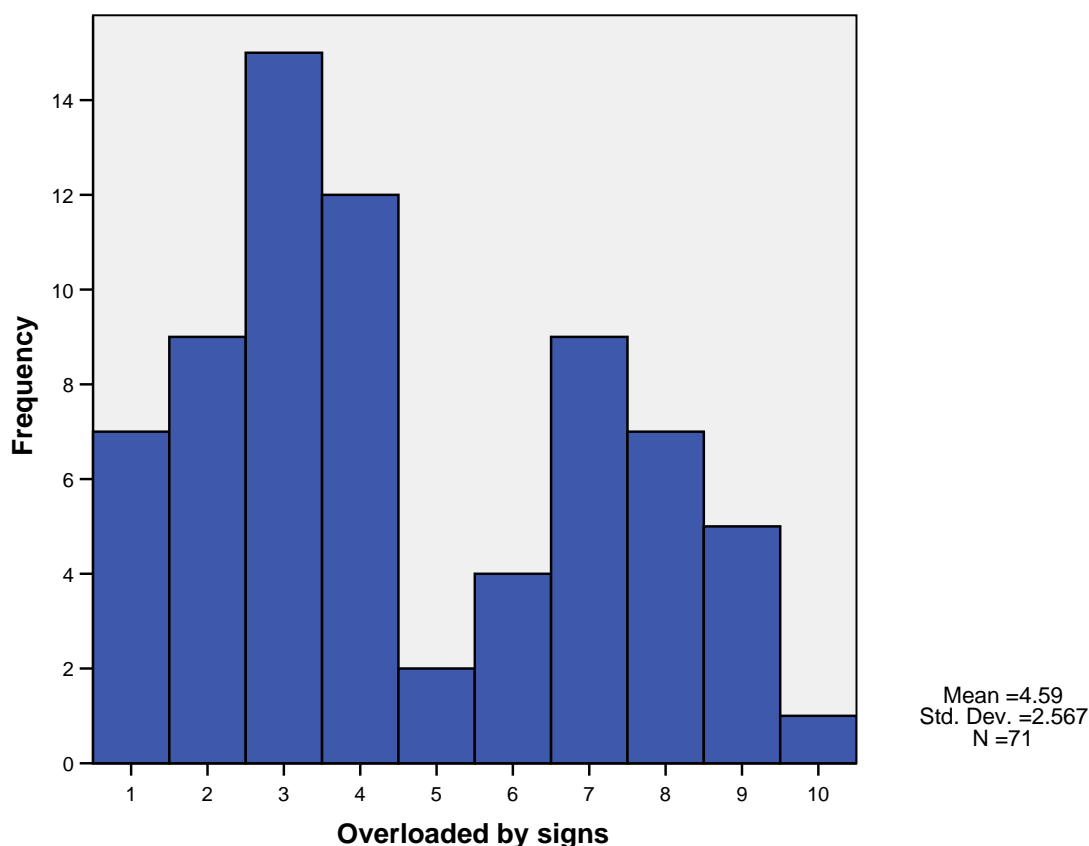


Figure 24: Frequency of participant scores in response to the number of signs

3.4.13 F10a – Lanes permitted to drive in when the vehicle is in VED band D

F10a was concerned with asking participants which lanes were permitted for a vehicle that is in VED band D. Table 10 below shows that 12 participants from the 71 participants providing an answer provided an incorrect response, with nine reporting that all four lanes were available to such a vehicle. 81.9% (n=59) correctly answered that lanes LBS1, LBS2 and LBS3 were the only lanes permitted for a band D vehicle. This suggests that participants had a relatively clear understanding of the restrictions that applied. No specific age effects can be shown by this result, as three old and three young participants in both categories of allowed and not allowed were incorrect. Furthermore no differences were found between informed and uninformed participants.

Table 10: Number of participants who incorrectly answered which lane a VED band D vehicle is permitted to use

Lanes	Allowed		Not allowed		Total
	Young	Old	Young	Old	
1,2,3,4	1	2	3	3	9
1,2	0	1	0	0	1
2,3	1	0	0	0	1
2	1	0	0	0	1
Total	3	3	3	3	12

3.4.14 F10b – Confidence

Participants were asked to rate their confidence level to the answer of which lanes they were permitted to drive in. Participants overall scored very confidently with a mean score of 8.1 (SD=2.2). Participants in the allowed group were slightly more confident in their choice of lanes to that of the not allowed group, with mean scores of 8.3 and 8.0 respectively. However these differences are very small, indicating that both groups were confident in their choice of lanes regardless of whether they were permitted to use the green lane or not.

3.4.15 F11a – Lanes permitted to drive in when the vehicle is in VED band B

This question requires participants to select which lanes a vehicle in VED band B would be permitted to drive in. Similar to that of F10a, 81.9% (n=59) of 71 participants correctly stated that all four lanes would be available for this vehicle. Table 11 displays the participants split for the incorrect responses.

Participants who tended to answer incorrectly were inclined to put lanes LBS1, LBS2 and LBS3, with 10 participants recording this response. It is surprising to note however that four older participants who were allowed to use the green lane responded this way. The two other responses indicated awareness that the green lane was available for this vehicle but failed to select all the correct lanes in which a band B vehicle could legitimately travel.

Table 11: Number of participants who incorrectly answered which lane a VED band B vehicle is permitted to use

Lanes	Allowed		Not allowed		Total
	Young	Old	Young	Old	
1,2,3	0	4	5	1	10
2,3,4	1	0	0	0	1
4	1	0	0	0	1
Total	2	4	5	1	12

3.4.16 F11b – Confidence

Further to the above question, participants were asked how confident they had felt with their selection of lane(s) for the VED band B vehicle. Participants overall stated a high level of confidence for this question with the mean reaching 8.3 (SD=2.2). Splitting into

allowed and not allowed categories, the mean was shown to be 8.5 (SD=2.3) for the allowed group and 8.0 (SD=2.2) for the not allowed. Participants in the allowed group again showed to have a higher confidence level in their responses compared to that of those in the not allowed group, even when the exact number of allowed and not allowed participants answered the question incorrectly.

3.4.17 F12 – How confident did the participant feel when driving on the motorway that included a green lane?

Participants were asked on a scale of 1-10 (1=not at all confident; 10=very confident), how confident they felt when driving on the motorway with the additional feature of a green lane. Analysing the two means of the informed and uninformed groups shows the informed participants were shown to be more confident (mean=7.6; SD=2.1) compared to that of the uninformed (mean=7; SD=2.5) this was expected due to the lack of information provided to the uninformed participants, however an independent measures *t* test was produced ($t(70)=1.17; p < 0.395$) confirming this difference not to be statistically significant. Mean confidence ratings were calculated for general motorway driving ($M=7.9; SD=1.3$) and motorway driving in the presence of green lane ($M=7.3; SD=2.3$). This difference was modest however was found to be significant at the 0.05 level ($t(71) = 2.14, p < 0.04$).

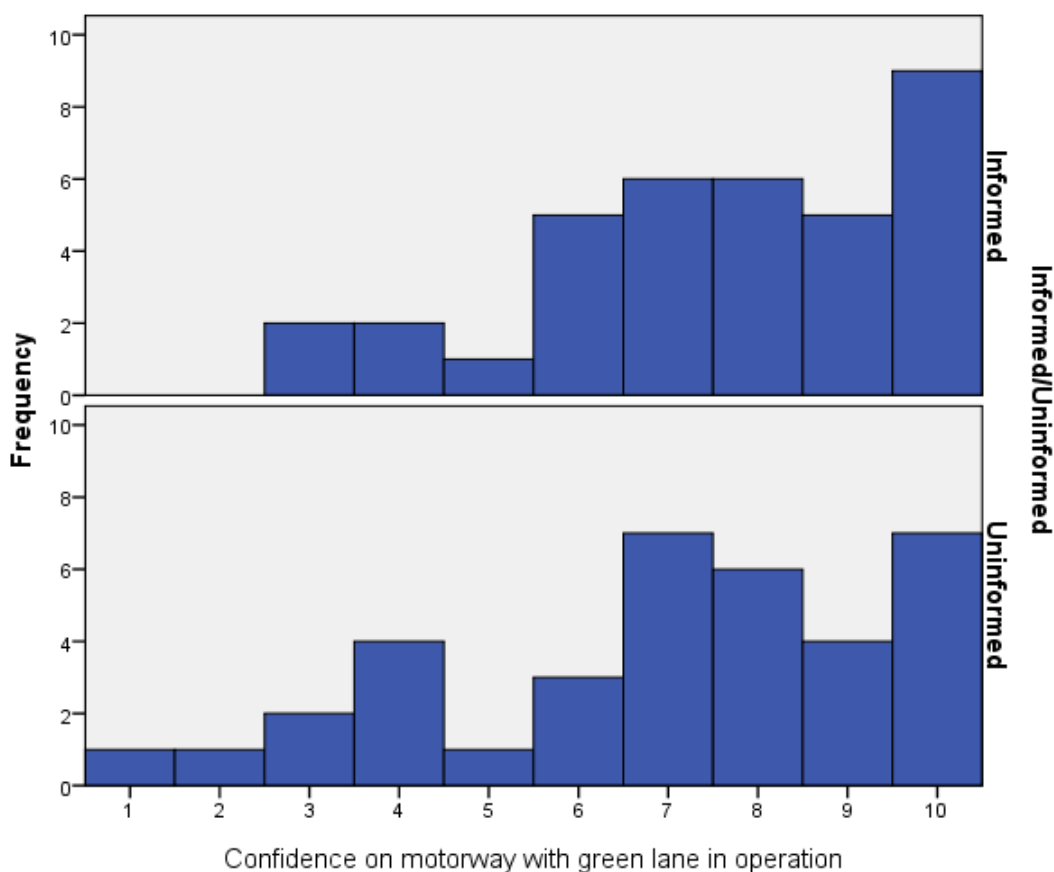


Figure 25: Participants’ mean confidence scores for driving on the motorway with a green lane operating

3.4.18 F13a – Participants understanding of whether they were permitted to cross the double white line

The green lane was separated from the normal running lanes by a double white line. Participants were asked to imagine their vehicle was permitted to travel in the green lane to answer this question. Respondents were required to answer whether or not they were permitted to cross the double line.

Table 12 below indicates that 21 participants were unaware that they were not permitted to cross the double white line. There was no significant difference between informed or uninformed participants in this question with approximately equal numbers in both. The number of participants giving an incorrect response from in the older category (14 incorrect responses) was double the number for participants in the younger category (7 incorrect responses). Overall there seems to be confusion over the correct usage of this road marking in the context of the green lane.

Table 12: Participant responses to whether they were permitted to cross the double white line

	Informed		Not informed		Total
	Young	Old	Young	Old	
Yes	3	8	4	6	21
No	14	11	15	11	51
Total					72

3.4.19 F13b - Confidence

Participants were again asked to rate their confidence in answer to the question of whether they were allowed to cross the double white line. Respondents overall were quite confident in their answers with an overall mean of 7.2 (SD=2.6). This only varied slightly when split between informed and uninformed and young and old participants, both of which fluctuated around the mean (0.1-0.2).

3.4.20 F14a - Permitted to undertake (i)

Undertaking was another aspect of the green lane scheme that required participant understanding. The following two questions were asked to illicit participant views of undertaking when in both lane LBS3 and the green lane.

For the first question, participants were asked if they were driving in lane LBS3 were they permitted to undertake vehicles travelling slowly in the green lane. Responses from participants indicated that 52 participants were aware that undertaking was permitted when in lane LBS3. 15 participants incorrectly stated that they were not allowed to undertake those in the green lane. 10 of these participants were part of the young group, in which eight were not allowed to use the green lane.

3.4.21 F14b – Confidence

Participants were also asked to rate how confident they were of their answer to whether they could overtake drivers in the green lane using lane LBS3. Confidence levels were relatively high (mean=7; SD=2.1). However when comparing this to sub groups, the confidence levels vary. Older participants overall were more confident (Mean=7.4; SD=2.30) than the younger drivers (mean=6.5; SD=1.8). Furthermore this increased when analysing allowed participants in the older age category, a mean of 8.2 (SD=1.7) was produced. Comparing to this of the younger section participants were found to be

less confident at a mean of 6.5 (SD=1.6). This indicates that older participants had a better understanding and felt more confident when using lane LBS3 to undertake.

3.4.22 F15a – Permitted to undertake (ii)

Participants were asked in this question whether they thought if they were behind slower moving vehicles in the green lane they could use lane LBS3 to undertake the slower vehicles before rejoining the green lane.

40% (n=29) of participants incorrectly stated that they could use lane 3 to undertake traffic travelling slowly in the green lane. 17 participants in the allowed category stated that they could undertake in this manner which is five more than in the not allowed category. No effects of age were recognised from the data. With only 43 participants correctly identifying that they were not permitted to undertake suggests that there was a lack of understanding of the regulations, showing that the presence of the green lane potentially could encourage undertaking.

3.4.23 F15b – Confidence

Participants rated their perceived confidence of their previous answer to question F15a. Overall a mean of 6.8 (SD=2.3) was recorded for the participants as a group. This is relatively low compared to previous scoring rates. However those in the allowed group had a much higher mean score (compared to the average) of 7.4 (SD=2.1) with the not allowed group scoring 6.2 (SD=2.4).

3.4.24 F16 – Participants understanding of driving with the green lane in operation

This question was concerned with when *not* driving in the green lane, did the participants felt that they were being held up by other vehicles due to the green lane being in operation.

Figure 26 illustrates the participants' responses to whether they felt held up due to the green lane being present. The overall mean (M=6.2; SD=2.8) suggests that participants did feel that the green lane did cause them to feel slowed by other vehicles.

Comparing the allowed and not allowed mean scores, naturally participants who were allowed in the green lane scored higher (mean=7.2; SD=2.3) compared to those who were not permitted to use the green lane (mean=5.2; SD=3.0). This indicates that participants who were not allowed to use the green lane perceived it as having a more negative impact on their journey time.

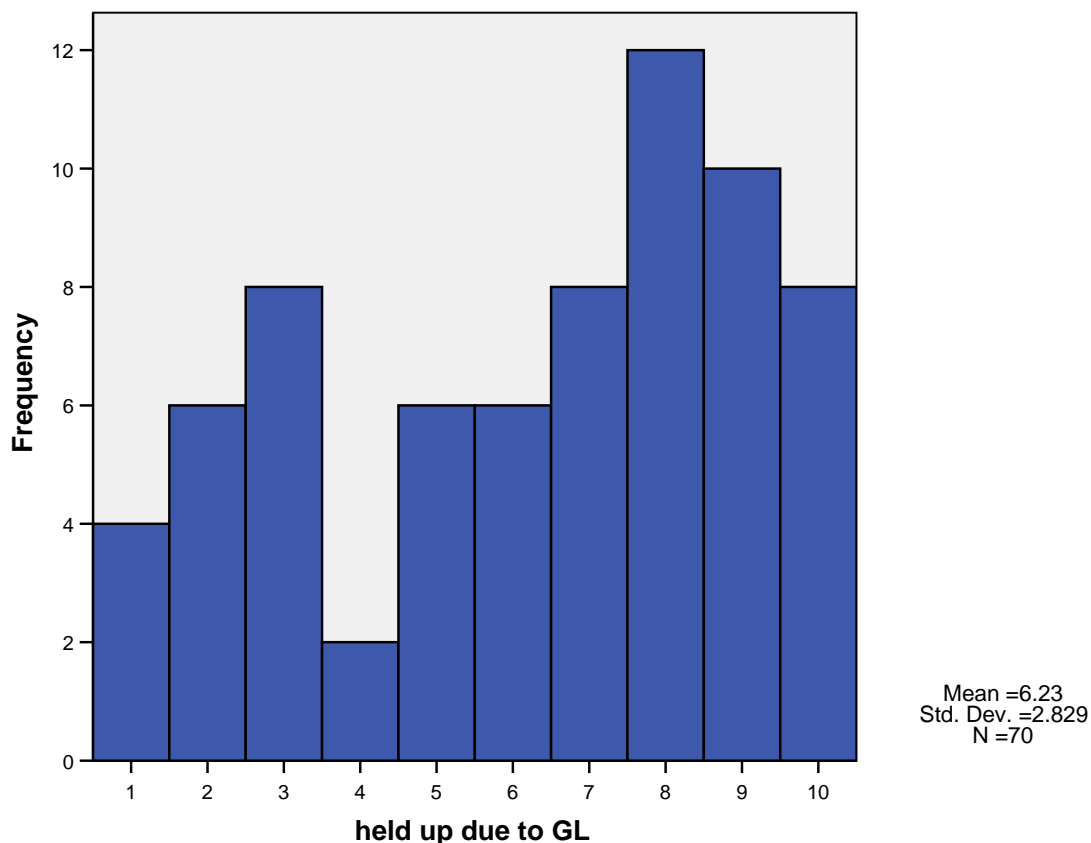


Figure 26: Participants responses to whether they felt held up by other vehicles with the green lane being in operation

3.5 General questions on green lane operation

3.5.1 G1 – Overall levels of congestion

Participants were asked in this question what effect would the green lane have on overall levels of congestion. (1=much less congestion; 10=much more congestion). The mean score was found to be 6.3 (SD; 2.0), when split into the allowed and not allowed groups, respondents in the allowed group recorded a mean of 6.0; (SD; 2.1) and those in the not allowed group scored a mean of 6.6 (SD; 1.9). Thus, participants that were not allowed to use the green lane thought the green lane would lead to more congestion.

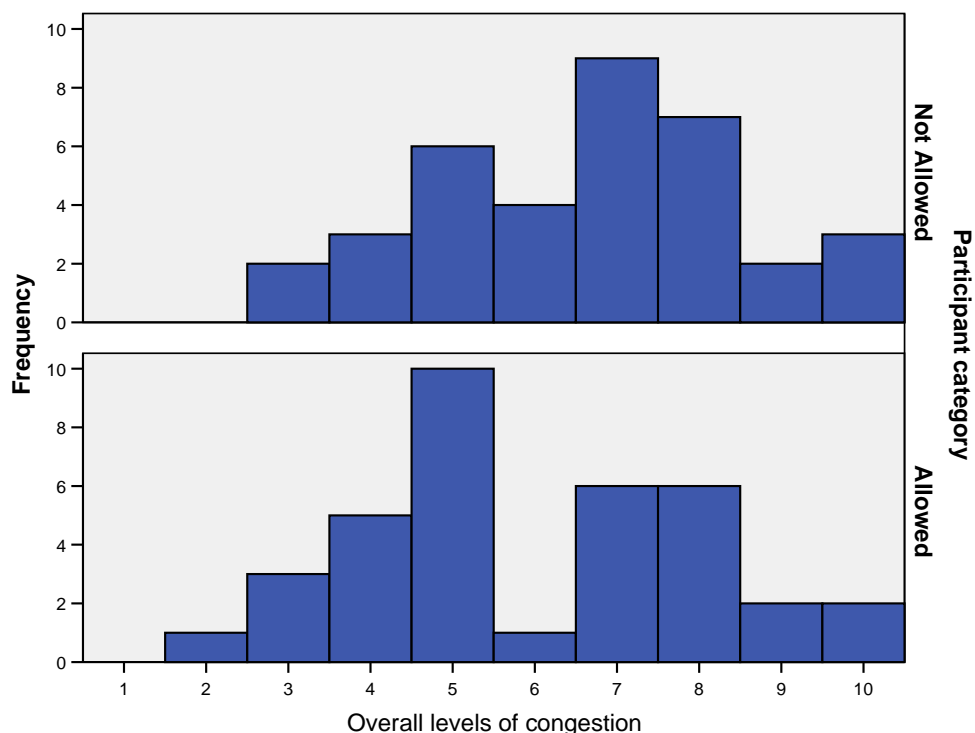


Figure 27: Participants' responses to the impact of the green lane on overall levels of congestion (G1)

3.5.2 G2 - Journey times

For question G2 participants were asked to rate on a 1-10 scale how they expected the green lane to effect their journey times (1=much slower; 10=much faster). A mean score of 5.1 (SD 2.0) was produced by participants as a whole, indicating that journey times would not change dramatically. Figure 28 compares the allowed and not allowed groups, participants in the allowed group were found to report a higher score of 5.9 (SD=2.1), with the not allowed group recording a mean of 4.3 (SD=1.8). The difference between the two sets of scores was found to be significantly different ($t(70) = 3.56, p < .001$). This suggests participants in the not allowed group foresee their journey times to be more negatively affected than those who are permitted to use the green lane.

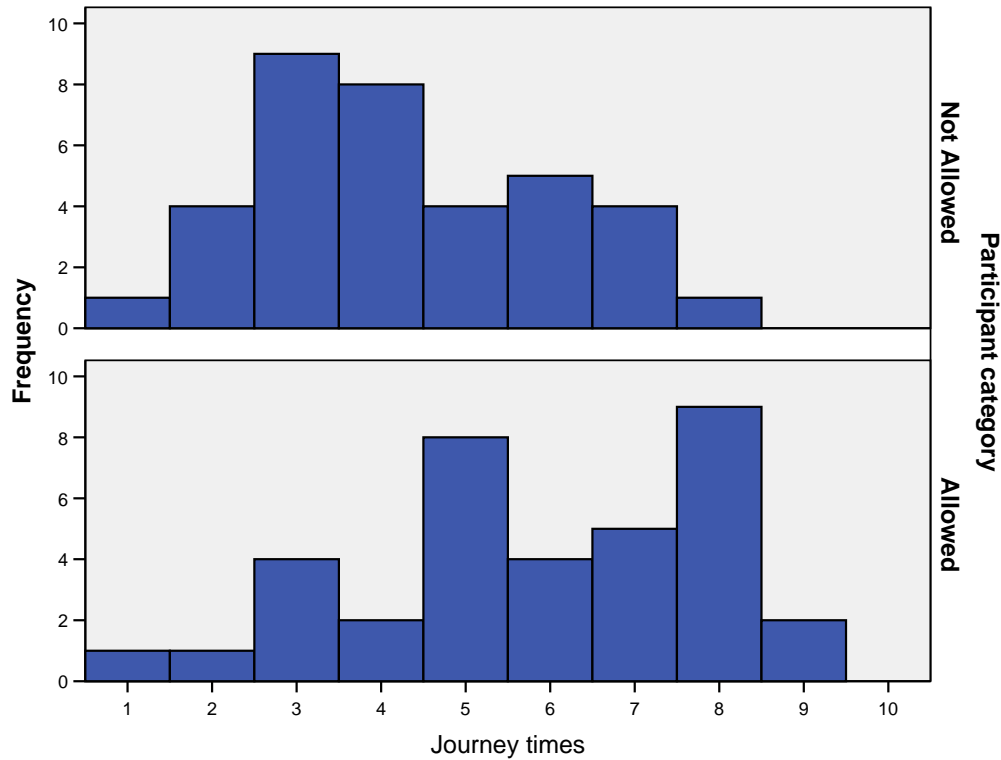


Figure 28: Participants responses to the impact of the green lane on journey times (G2)

3.5.3 G3 – Predictability of journey times

In question G3 participants were asked what the effect of the green lane would have on predictability of journey time, a scale of 1-10 was used (1=much less predictable; 10=much more predictable). Overall participants recorded a mean of 4.8 (SD=1.8). Splitting into the two groups of allowed and not allowed displayed a significant difference between scores (Figure 29). Participants in the allowed group felt a slight positive effect of predictability of journey time (mean=5.6; SD=1.7) compared to that of the not allowed group who gave a slightly negative score of 4.0 (SD=1.5). An independent t test was calculated, which showed this difference to be statistically significant ($t(70) = 4.05, p < 0.001$).

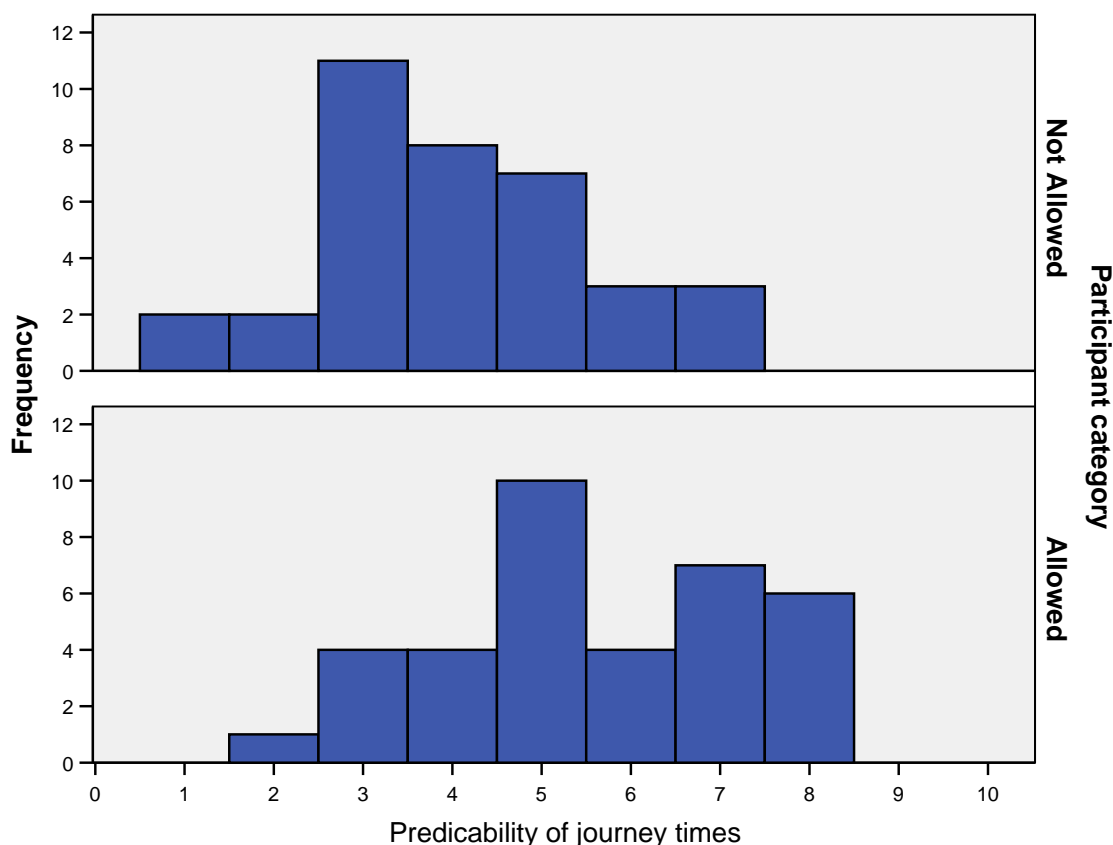


Figure 29: Participants responses to the impact of the green lane on predictability of journey times (G3)

3.5.4 G4 – Environmental conditions

Participants were asked to rate how a green lane could potentially affect the environment. A scale of 1-10 was used, with 1 being "Much less damaging" and 10 being "Much more damaging" (Figure 29). Overall participants felt quite neutral with a mean score of 4.8 (SD= 1.9). Allowed participants were shown to have a mean score of 4.5 and not allowed participants displayed a mean of 5.0 (SD=1.8) indicating that both groups do not think that a green lane would increase or decrease damage to the environment. Please note one participant scored 0.5 for this question, hence why the graph reads from 0-10 in rating score.

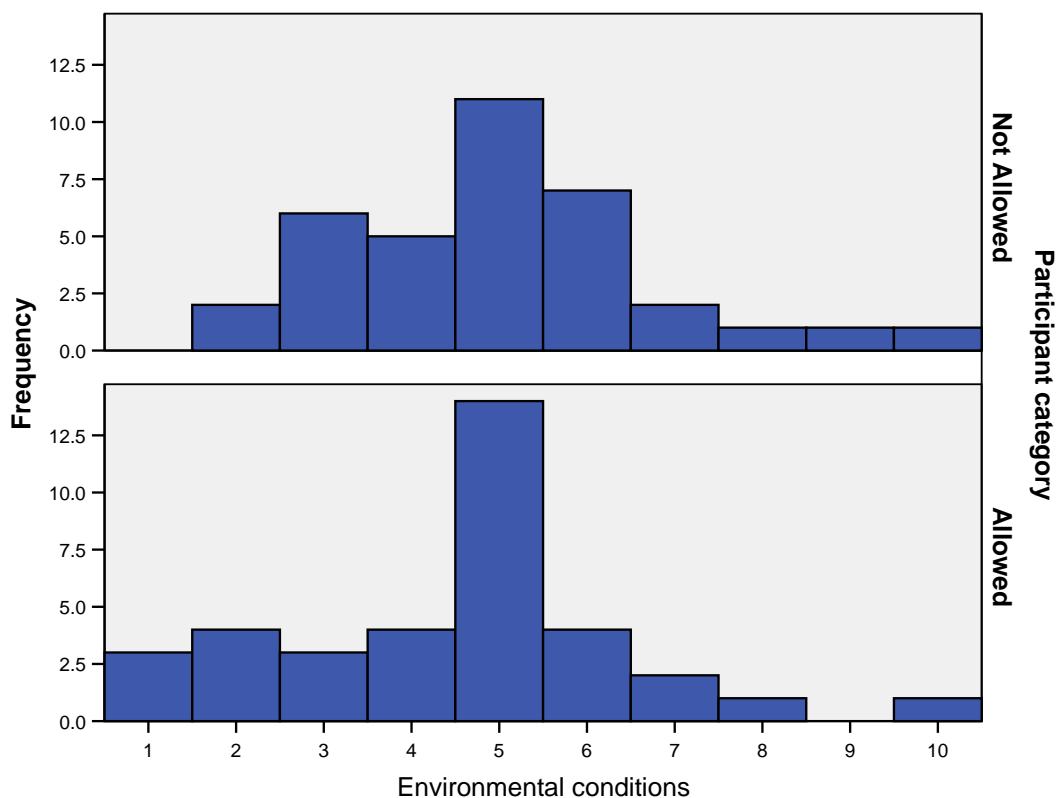


Figure 30: Participant responses to the impact of a green lane on environmental conditions (G4)

3.5.5 G5 – Number of accidents

Participants were required to rate how the green lane would affect the number of accidents if it was introduced onto the road network. Scores were rated on a 1-10 scale (1=Many fewer accidents; 10=Many more accidents). Figure 31 illustrates the spread of scores for allowed and not allowed participants. The not allowed group overall scored 6.8 (SD=1.5) with the graph showing a concentrate of answers around the higher end of the scale, with no respondents scoring below 5. The allowed category demonstrated a larger distribution of scores with the mean reaching 5.9 (SD= 1.7). An independent samples t-test demonstrated the difference between the groups' scores to be statistically significant ($t(70) = -2.4, p < .019$), therefore the participants who were permitted to use the green lane estimated fewer accidents than those who were using only normal running lanes.

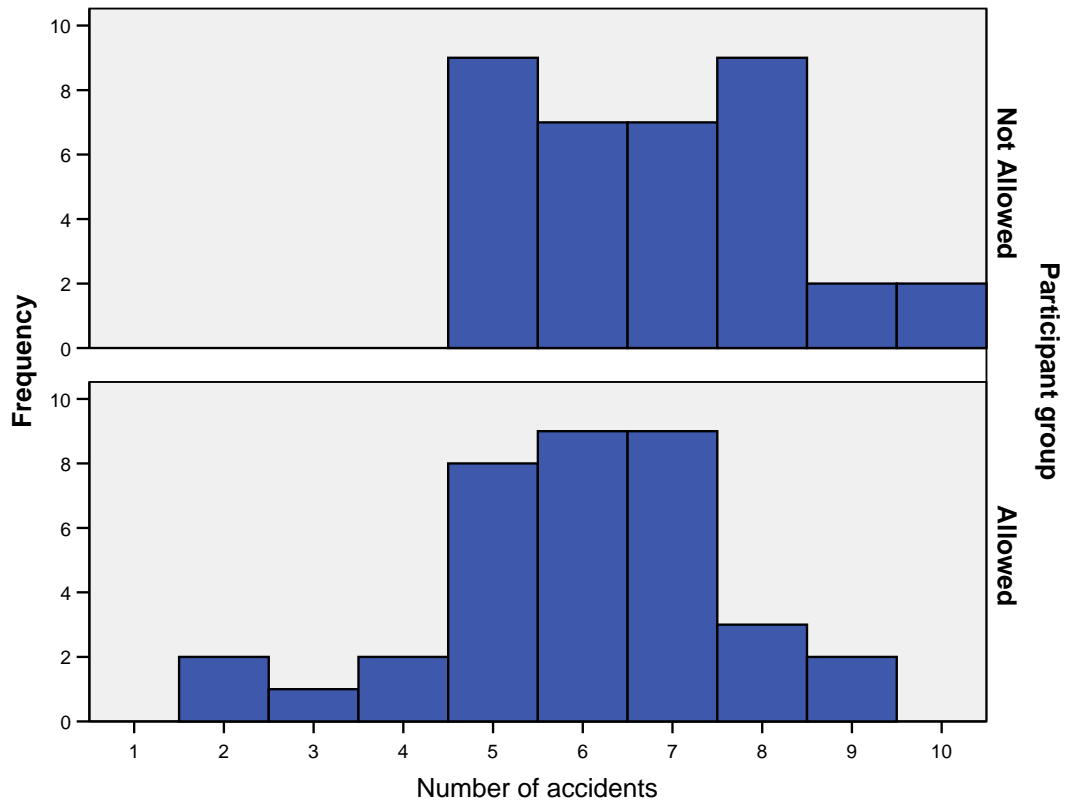


Figure 31: Participants responses to the impact of a green lane on the number of accidents (G5)

3.5.6 G6 - Severity of accidents

Participants rated on a scale of 1-10 (1=Much less serious; 10=Much more serious) of their opinion of how the green lane could potentially affect the severity of accidents (Figure 32). An overall mean for all participants was calculated at 5.9 (SD=1.5) indicating a slight prevalence towards the green lane causing more serious accidents. Groups individually fluctuated around this mean with allowed participants scoring slightly lower (mean=5.8; SD=1.4) and those who were not allowed in the green lane producing a mean of 6.0 (SD=1.7). Thus indicating those that who were not permitted to use the green lane indicating a potential increase in the severity of accidents. These differences however are not statistically significant.

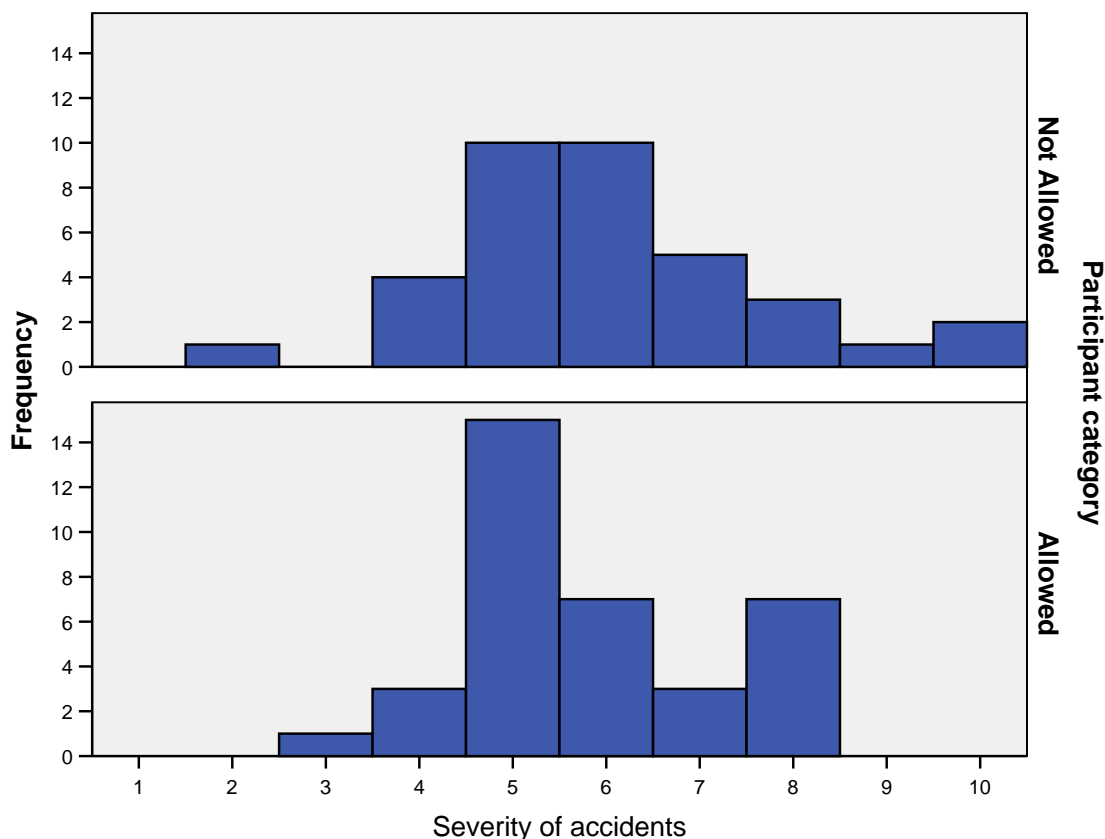


Figure 32: Participant responses to the impact of a green lane on the severity of accidents (G6)

4 General discussion

4.1 Driving behaviour

Overall, it was observed that participants that were allowed to use the green lane made extensive use of it. However, in the first green lane scheme junction, it was also observed that a considerable proportion of participants that were not allowed to use the green lane nevertheless did so, even when they were informed as to the workings of the scheme. This is surprising although it should be noted that those who illegally drove in the green lane did so for only a small proportion of the time. Furthermore, in Junction 2 and 4, it was observed that despite the higher speed limits in the green lane, this did not lead to an increase in illegitimate use of the green lane.

Upon exiting the motorway, a proportion of green lane users illegitimately crossed the double white lines and failed to use the egress zone to leave the green lane. This finding suggests that for some drivers, the start of egress zone is too late for them to leave the motorway comfortably. This appeared to be the case for older drivers in particular.

When considering the position at which participants entered LBS1 to leave the motorway, there was no appreciable difference between the green lane and non-green lane users. This suggests that the egress zone was of sufficient length to arrive in LBS1 in a timely manner. These findings are contrast with those obtained in the Single Lane Tolling study in which it was found that participants using the toll lane arrived much later in LBS1 to exit the motorway. It is possible that results here are skewed by the illegitimate crossing of the double white line by some green lane users.

Concerning illegal use of the green lane, it was noted overall that 11 participants illegitimately used the green lane. Of these participants eight were in the not allowed/uninformed group, with one female older participant contravening the green lane four times over the length of the trial. Interestingly though the participant that had the highest frequency of illegitimate use was in the not allowed/informed group, they accessed the green lane five times within their drive. This potentially could have been due to a misunderstanding of the instructions given or alternatively purposeful disregard of the restrictions of the green lane. However, most of the 11 of the participants were only in the green lane for a brief time, suggesting that a realisation of the restrictions of the green lane could have prompted a return to the alternative lanes. It can therefore be seen overall that participants may not have had a clear comprehension initially of green lane use but a reduction of illegal use was seen when participants became more familiar with the road layout and sign instructions further into the drive.

4.2 Questionnaire

A considerable proportion of participants in both the informed and uninformed group were not completely clear where and when to join the green lane suggests the current signs and markings are not yet optimal. Similarly, not all participants (and in particular uninformed participants) were completely clear about the restrictions that applied on approach to the green lane scheme. A considerable proportion also failed to understand what the consequences were for green lane use for vehicles within a specific VED band. Not all participants understood that it was not allowed to cross the double white lines of the green lane. It is further of interest to note that within the participant sample, a considerable proportion indicated that they felt overloaded by the signs. These tended to be older and uninformed participants. The above findings suggest that the signs and markings failed to convey the workings of the green lane scheme completely and optimisation of the information provision within a scheme such as the green lane would be beneficial.

Furthermore, when asked about the clarity of the workings of the green lane scheme, it was found that, overall, uninformed participants were less clear and illustrates the importance of public information provision when introducing new road schemes.

Finally, it was found that those participants that were allowed to use the green lane and had experienced the green lane scheme in the driving simulator expressed a much more positive attitude toward the scheme with regards to its effect on congestion, journey time, as well as road safety. In addition, they were more confident in their driving within the green lane scheme.

The results indicated that more than half the participants in both the informed and uninformed groups thought they were not allowed to undertake traffic in the green lane. Note that this may cause an undesirable situation when traffic in the green lane is travelling at lower speeds than that in the normal running lanes and suggests an important role for public information provision when introducing such a scheme.

4.3 Safety interpretation

The use of a Designated Lane represents a major departure from current motorway practice in the UK. In the case of this study the designated lane (DL) is a green lane (GL) and full time through junction running (FT TJR) on the hard shoulder was also operated. The use of the DL as a GL raises some potential safety issues which are in common with the operation of DLs in general and others which are specifically related to the operation of a GL.

As the GL is adjacent to the median, drivers that use it have to cross all the other lanes when they wish to leave the motorway at a junction and also to cross all the other lanes when they enter the motorway. This additional lane changing may increase the risk of an accident.

On the approach to a GL, drivers in the median lane who are not permitted to use the GL will need to vacate the median lane and at the end of the GL may wish to move back on to the median lane. This additional lane changing may increase the risk of an accident.

The lane changing mentioned above is likely to affect the behaviour of other drivers in terms of their lane usage and the lane changing associated with it.

Some vehicles with low emissions may be relatively underpowered leading to relatively poor ability to accelerate. These would be those with relatively small internal combustion engines and electrically powered vehicles. These may have some difficulty getting to the GL which may have safety implications. They may also travel relatively slowly (for example, the driver of an electrically powered vehicle trying to extend the range that the battery can provide before it becomes discharged). Such vehicles would tend to block the GL.

Vehicles using the GL may leave it to undertake slower vehicles ahead of them in the GL. This is illegal if they cross the double solid white line separating the GL from the other lanes but is legal elsewhere. As ever, additional lane changing has the potential to increase accidents. Furthermore, such undertaking behaviour might lead to a more general acceptance of undertaking on other sections of motorway. If drivers are trapped in a GL, this becomes more of an issue for longer GLs.

If the hard shoulder is closed and there is a GL, then the motorway is effectively dual 2-lane as far as the traffic not using the GL is concerned and this could cause a good deal of frustration especially where the proportion of heavy goods vehicles is high, since when the latter overtake each other as they commonly do, they will block the available lanes. This may have safety implications.

During the simulation experiments, the participants in general understood the signing and marking and behaved in a sensible manner. This suggests that safety is not likely to be seriously compromised if GLs are introduced.

There were, however, a significant number of participants who in the questionnaire were uncertain as to whether they were permitted to cross the double white line and an even greater number believed they were permitted to undertake slower vehicles before rejoining the GL.

In the questionnaire, the vast majority of the participants, whether or not they were in the group that were permitted to use the GL, thought that the use of a GL would either be neutral or would increase the number of accidents. There was also a slight prevalence towards the view that the GL would increase the severity of accidents.

There are clearly some concerns about the potential for the use of GLs to increase accident risk. Whether this would be the case in practice is only likely to be known after a number of schemes have been in operation for some considerable period of time. Inevitably, some drivers will initially have uncertainties about how they should behave and also how other drivers will respond to GLs which could compromise safety to some extent. However, as with many novel systems, drivers will undertake a learning process over time in how to behave where these systems are operated.

It is also worth noting that these experiments were undertaken on a route where the hard shoulder was used as a running lane at some locations and at others where it was not. Thus, the drivers had to cope with two novel systems and not with GL alone. All other things being equal, it seems likely that the more complex the scheme and the resulting increase on the demands of the drivers, the greater will be the potential for reduced safety. Having said that, there was no outcome from the experiments that suggest that GL operation would be likely to be a disaster from the point of view of safety.

4.4 Network performance interpretation

To maximise network performance, any effects that would reduce capacity should be minimised. A reduction in capacity could occur in several ways:

- Drivers might slow down while assimilating information, causing drivers behind to brake, which could cause shockwaves during periods of high flow. This is most likely to occur as drivers approach the start of the green lane, either because they are unfamiliar with the concept, or because they are deciding whether they are permitted to use the lane. This could be mediated by providing high levels of publicity prior to the scheme being implemented, so that drivers know what to expect as they approach a green lane scheme. The simulator study showed that drivers who were not allowed to use the green lane travelled significantly slower on the final approach to the start of the green lane than drivers who were permitted to use the lane.
- Additional or more sudden lane changing might cause following drivers to brake. The simulator study suggests that the amount of lane changing is unlikely to increase following the implementation of green lane schemes, as there will be little lane changing between lanes 3 and 4 (the green lane) along a link.

Drivers in the green lane who wish to leave at the next junction could cause braking as they change lanes into relatively small gaps. In a previous trial for single lane tolling (using the same road layout), drivers in the dedicated lane often changed lanes suddenly when moving from the offside lane to the exit slip. This behaviour was not observed during the green lane simulator trial; however, several drivers left the green lane early (crossing a solid white line to do so) in order to access the exit slip. Neither behaviour is appropriate; this could be addressed by making the access zone on the approach to exit slips longer, so that drivers could legally leave the green lane earlier, allowing more time for them to move into lane 1 prior to the exit slip.

There might also be weaving within the access zone, with drivers using the zone to overtake. The simulator study showed that this behaviour was most common in uninformed drivers; advance publicity for the scheme should reduce this behaviour.

- Capacity will be reduced if the green lane is under-utilised. This will not be an issue off-peak, as the remaining lanes will be able to cope with the demand, but if this occurs during periods of high flow, congestion will be caused unnecessarily.

To address this issue, the eligibility criteria for using the green lane should be set so that at least 20% of cars are allowed to use the lane during periods of high flow.

5 Conclusion

Drivers' responses to the GL were largely in line with expectations and predict largely positive outcome for such schemes with some concerns about drivers' understanding and behaviour.

- The majority of participants responded to the green lane scheme in a correct and safe manner
- Illegitimate use of the green lane decreased with familiarity of the scheme
- Signs indicating the commencement of the green lane were not well understood by all participants as some illegal use of the green lane was noted.
- Reduced confidence of uninformed drivers using the scheme indicated a need for good public information when introducing such a scheme.
- Trial outcomes suggest that there were some safety concerns over drivers' understanding of the scheme design and whether this would lead to higher levels of undertaking.
- A safety concern was also raised that the introduction of such a designated lane would require increased lane changing to access/egress the lane.
- To maximise network performance the eligibility criteria for using the green lane should be set so that at least 20% of cars are allowed to use the lane during periods of high flow.

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References

Diels, C., Reed, N., Walker, R., Robbins, R., Rees, T., Rillie, I., Parkes, A.M. (2008) Single Lane Tolling Simulation Study – Client Project Report (CPR 226), Wokingham, Berkshire: Transport Research Laboratory (TRL).

Diels, C., Reed, N., Robbins, R., Rees, T., Rillie, I., Parkes, A.M. (2009a) Through Junction Running Simulation Study - Published Project Report (PPR 430), Wokingham, Berkshire: Transport Research Laboratory (TRL).

Diels, C., Rees, T., Summersgill, I. (2009b) Part Time Through Junction Running Simulation Study - Published Project Report (PPR 431), Wokingham, Berkshire: Transport Research Laboratory (TRL).

Schlag, B (1993) Elderly drivers in Germany: fitness and driving behaviour. *Accident Analysis and Prevention*, 25, 47-55.

Glossary of terms and abbreviations

ERA: Emergency Refuge Area

FT TJR: Full Time Through Junction Running

GL: Green Lane

HS: Hard Shoulder

HSR: Hard Shoulder Running

LBS1: Lane Below Signal 1 (The Hard Shoulder)

LBS2: Lane Below Signal 2

LBS3: Lane Below Signal 3

LBS4: Lane Below Signal 4

PT TJR: Part Time Through Junction Running

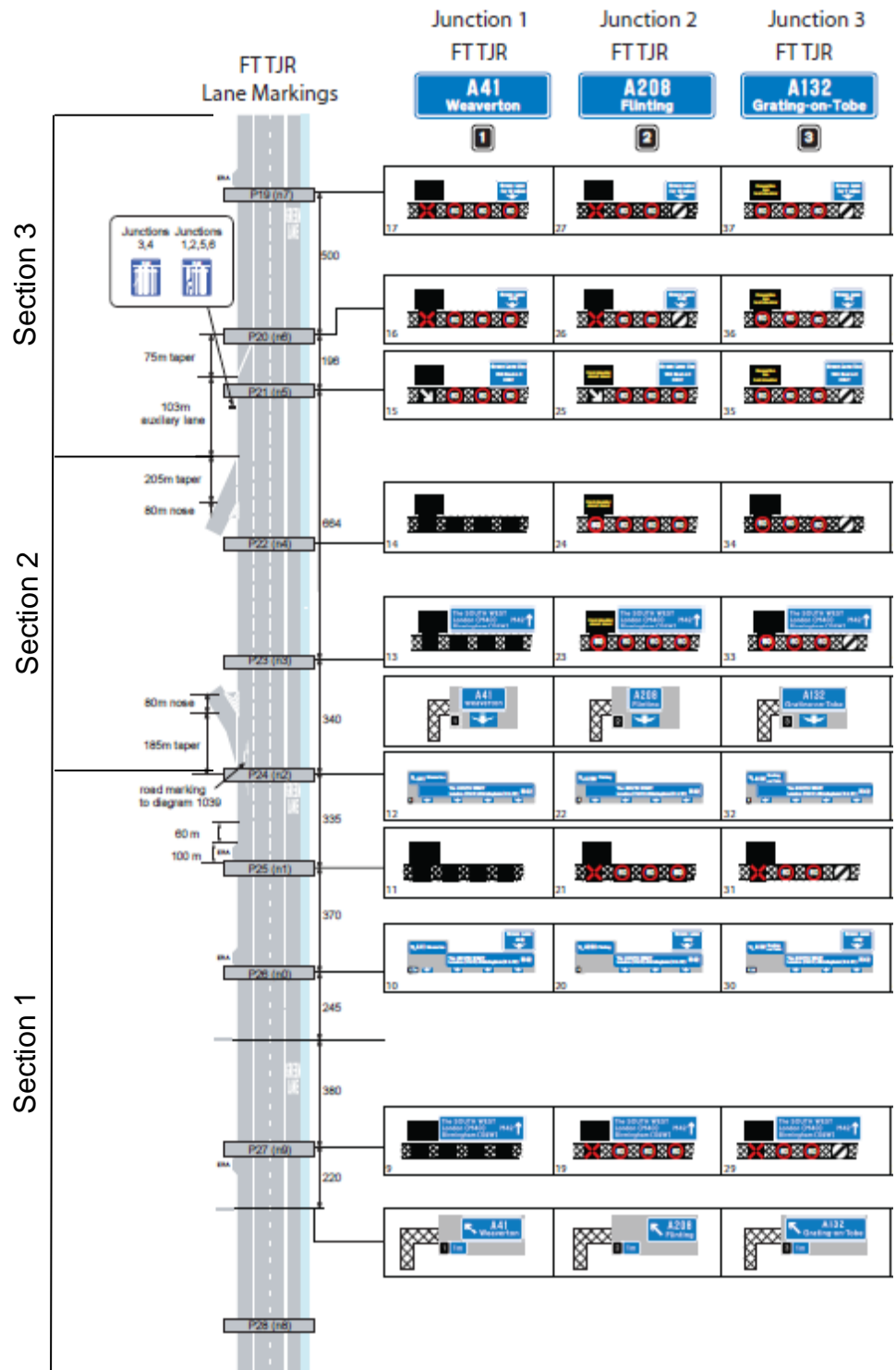
TJR: Through Junction Running

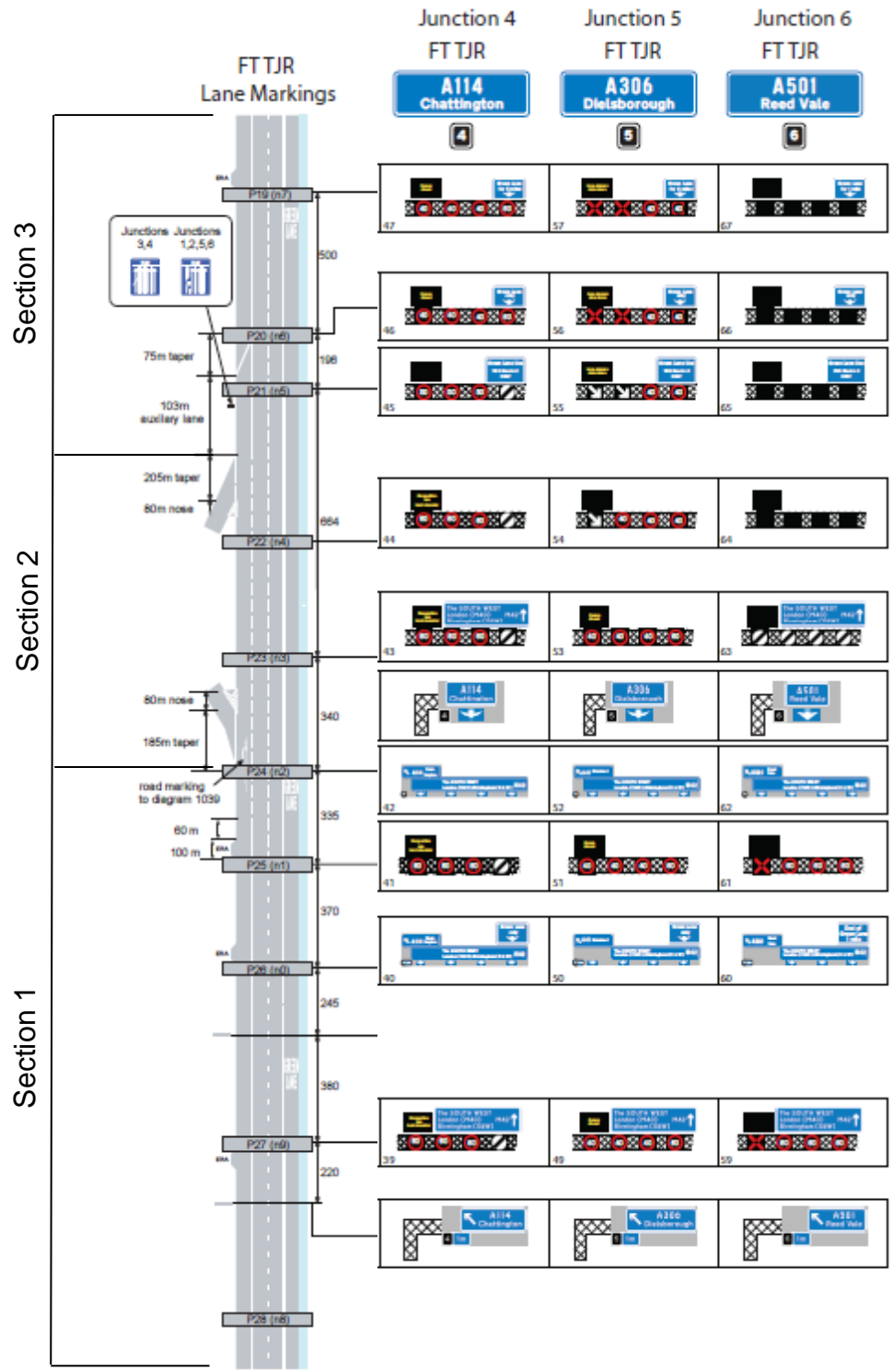
TO: Traffic Officer

VMS: Variable Message Sign

VSL: Variable Speed Limit

Appendix A – Route summary





Appendix B – Questionnaire

SECTION E										
YOUR EXPERIENCE DURING FULL TIME THROUGH JUNCTION RUNNING WITH A GREEN LANE										
E1. How safe did you feel during your drive in the following situations?										
<i>(Please circle the number you feel is most appropriate, if you did not experience the situation please leave the question blank)</i>										
	Not at all safe									Very safe
	1	2	3	4	5	6	7	8	9	10
<i>a. Driving in general</i>	1	2	3	4	5	6	7	8	9	10
<i>b. Driving in lane 1 (former hard shoulder) between junctions</i>	1	2	3	4	5	6	7	8	9	10
<i>c. Driving in lane 1 (former hard shoulder) within junctions</i>	1	2	3	4	5	6	7	8	9	10
<i>d. Driving in lane 2</i>	1	2	3	4	5	6	7	8	9	10
<i>e. Driving in lane 3</i>	1	2	3	4	5	6	7	8	9	10
<i>f. Driving in the green lane (lane 4)</i>	1	2	3	4	5	6	7	8	9	10
<i>g. Leaving the motorway when the hard shoulder is open</i>	1	2	3	4	5	6	7	8	9	10
<i>h. Rejoining the motorway when the hard shoulder is open</i>	1	2	3	4	5	6	7	8	9	10
<i>i. Driving when the national speed limit applied</i>	1	2	3	4	5	6	7	8	9	10
<i>j. Leaving the motorway from the green lane</i>	1	2	3	4	5	6	7	8	9	10
<i>k. Rejoining the motorway and making your way over to the designated lane</i>	1	2	3	4	5	6	7	8	9	10
<i>l. Driving when a 60mph speed limit applied</i>	1	2	3	4	5	6	7	8	9	10
<i>m. Driving under conditions in which speed limits differed for different lanes</i>	1	2	3	4	5	6	7	8	9	10
<i>n. Approaching a junction</i>	1	2	3	4	5	6	7	8	9	10
<i>o. Passing an entrance slip road</i>	1	2	3	4	5	6	7	8	9	10

<i>p. Overtaking another vehicle</i>	1	2	3	4	5	6	7	8	9	10
<i>q. Being overtaken by another vehicle</i>	1	2	3	4	5	6	7	8	9	10
<i>r. Being undertaken by another vehicle</i>	1	2	3	4	5	6	7	8	9	10
<i>s. Entering the green lane</i>	1	2	3	4	5	6	7	8	9	10
<i>t. Leaving the green lane</i>	1	2	3	4	5	6	7	8	9	10
<i>u. Driving with light traffic</i>	1	2	3	4	5	6	7	8	9	10
<i>v. Driving with heavy traffic</i>	1	2	3	4	5	6	7	8	9	10

SECTION F

Please refer to the pictures provided

Referring to PICTURE 1

F1. Please rate how clear you felt the signs were that indicated that a green lane was going to commence?

*Completely unclear**Completely clear*

1	2	3	4	5	6	7	8	9	10
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F2. On approach to the green lane scheme, were you aware of the restrictions that applied?

*Completely unaware**Completely aware*

1	2	3	4	5	6	7	8	9	10
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Referring to PICTURE 2

F3. When the green lane scheme had started, please rate how clear it was where and when to join the designated green lane?

*Completely unclear**Completely clear*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

F4. When the green lane scheme had started, please rate how clear you felt the indication was of which lanes you were permitted to travel in?

*Completely unclear**Completely clear*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

F5. Did you feel that the sign and road markings clearly indicated which lanes you were permitted to travel in?

*Completely unclear**Completely clear*

1	2	3	4	5	6	7	8	9	10
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F6a. In the simulator trial, which lanes were you permitted to travel in?									
<i>(Please select one or more lanes as appropriate)</i>									
	A	B	C	D					
F6b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10

Referring to PICTURE 3									
F7a. When lane A was closed, would you have been permitted to travel in the green lane?									
<i>Yes</i>			<i>No</i>						
F7b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10

Referring to PICTURE 4									
F8a. When lanes A and B were closed, would you have been permitted to travel in the green lane?									
<i>Yes</i>			<i>No</i>						
F8b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F9. Whether or not you were driving in the green lane, did you feel like you were overloaded with the number of signs?									
<i>Not at all</i>					<i>Very much so</i>				
1	2	3	4	5	6	7	8	9	10

Referring to PICTURE 5									
F10a. Imagine the vehicle you are driving is in VED band D. Which lanes are you permitted to travel in?									
<i>(Please select one or more lanes as appropriate)</i>									
	A	B	C	D					
F10b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10

Referring to PICTURE 5									
F11a. Imagine the vehicle you are driving is in VED band B. Which lanes are you permitted to travel in?									
<i>(Please select one or more lanes as appropriate)</i>									
	A	B	C	D					
F11b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F12. How confident did you feel when driving on the motorway that included a green lane?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F13a. Imagine your vehicle allows you access to the green lane, are you permitted to cross the double white line that divides the green lane and the three normal running lanes?									
<i>Yes</i>			<i>No</i>						
F13b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F14a. When driving in lane 3, are you permitted to undertake vehicles travelling slowly in the green lane (Lane 4)?									
<i>Yes</i>			<i>No</i>						
F14b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F15a. When driving in the designated green lane, are you permitted to use Lane 3 to undertake vehicles travelling slowly in the green lane (Lane 4)?									
<i>Yes</i>			<i>No</i>						
F15b. How confident are you that the answer you have given is correct?									
<i>Not at all confident</i>					<i>Very confident</i>				
1	2	3	4	5	6	7	8	9	10
F16. When <i>not</i> driving in the green lane, did you feel you were being held up by other vehicles due to the green lane being in operation?									
<i>Not at all</i>					<i>Very much so</i>				
1	2	3	4	5	6	7	8	9	10

F17. Please give us any comments you have regarding the signs and road markings.

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**SECTION G
GENERAL COMMENTS**

If implemented, what effect do you think wider introduction of a **green lane** would have on the following:

	<i>Much less congestion</i>					<i>Much more congestion</i>				
G1. overall levels of congestion	1	2	3	4	5	6	7	8	9	10
	<i>Much slower</i>					<i>Much faster</i>				
G2. your journey times	1	2	3	4	5	6	7	8	9	10
	<i>Much less predictable</i>					<i>Much more predictable</i>				
G3. predictability of journey times	1	2	3	4	5	6	7	8	9	10
	<i>Much less damaging</i>					<i>Much more damaging</i>				
G4. environmental conditions	1	2	3	4	5	6	7	8	9	10
	<i>Many fewer accidents</i>					<i>Many more accidents</i>				
G5. number of accidents	1	2	3	4	5	6	7	8	9	10
	<i>Much less serious</i>					<i>Much more serious</i>				

Appendix C – Participant instructions

FT TJR Participant instructions

Beside the car:

Instruction in blue would already have been read to the participant in the familiarisation just a quick reminder is necessary.

Please adjust the seat position and secure the safety belt. The car controls work in the same manner as any normal car and it operates with a manual gearbox.

You need to make sure the car is in neutral when you start it (and it needs plenty of revs, otherwise it has a tendency to stall).

It is important that you drive as you would normally. We don't want you to drive as if you are on a driving test nor as if the simulation is a computer game. We are not here to judge your driving, so please do not feel anxious. Your driving is not being assessed

Route one

For the trial today please stay on the motorway unless instructed otherwise. During the drive, you will encounter sections where the hard shoulder can be used as a normal running lane. Please use the hard shoulder if you feel it is safe and appropriate to do so.

Twice in the drive you will be required to leave the motorway at particular exits, these are **Grating on Tobe and Reed Vale** and then rejoin the motorway by taking the first exit at the roundabout that you reach at the top of the slip road.

Please note that the vehicle has been limited to **75 mph** for this trial.

Route two

For the trial today please stay on the motorway unless instructed otherwise. During the drive, you will encounter sections where the hard shoulder can be used as a normal running lane. Please use the hard shoulder if you feel it is safe and appropriate to do so.

Once in the drive you will be required to leave the motorway at a particular exit, the exit is **Grating on Tobe** and then rejoin the motorway by taking the first exit at the roundabout that you reach at the top of the slip road.

Please note that the vehicle has been limited to **75 mph** for this trial.

Green Lane

Use FTTJR instructions in blue italics if first drive.

For the trial today please imagine that you are late for an important meeting and must hurry to get there on time.

During the drive, you will encounter sections where the hard shoulder can be used as a normal running lane. Please use the hard shoulder if you feel it is safe and appropriate to do so.

Once in the drive you will be required to leave the motorway at a particular exit, the exit is **Grating on Tobe** and then rejoin the motorway by taking the first exit at the roundabout that you reach at the top of the slip road.

Informed ONLY

The motorway that you are about to drive has a so-called 'green lane'. This is similar to a car-share lane except that rather than the lane being reserved for vehicles with two or more passengers, the lane is reserved for vehicles that are beneath a certain emissions threshold.

For the purposes of this trial, we have based the conditions for use of the green lane on the Vehicle Excise Duty (VED) bands – commonly known as road tax.

Vehicles in emissions bands A-C **are** permitted to use the green lane

Vehicles in emissions bands D-G **are not** permitted to use the green lane

Signs and road markings will indicate where the green lane starts and finishes.

Allowed: You are allowed to use the Green lane as the vehicle you are driving is in VED band C

Not Allowed: You are not allowed to use the Green lane as the vehicle you are driving is in VED band D

Uninformed ONLY

(Allowed): The vehicle you are driving is in VED band C

(Not Allowed): The vehicle you are driving is in VED band D

Only if asked by participant: A voice instruction will remind you where to exit.

From the Control Room:

Start: *Please start the engine using the ignition key and proceed, driving as you would normally.*