Experimental and Stated Preference study of the factors that influence driver frustration on the A9

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1 Introduction

1.1 Driver frustration

Koorey (2007) asserts "…passing opportunities generate economic benefits by reducing travel times, as they release impeded vehicles from platoons. …When drivers cannot overtake slower vehicles owing to a lack of passing opportunities, they are likely to become frustrated. This can lead to an increase in unsafe passing manoeuvres, which in turn can lead to crashes".

This quote not only summarises the engineer's viewpoint but that of many others, professional and public. Even a brief search of the internet reveals that driver frustration is a deep-seated issue. However, despite, or possibly because of, the widely held belief that frustration can lead to dangerous overtaking, the empirical evidence for this is sparse. Furthermore, the antecedents of driver frustration itself are not understood.

In 2012, Transport Scotland commissioned a review of the international literature on frustration and overtaking. This review (Grayson, Kinnear & Helman, In press) concluded that the concept of frustration appears in historic traffic modelling work that attempts to quantify drivers' perceptions of service quality. However, it tends to have been inferred from traffic variables rather than being measured directly. Two exceptions to this are the work of Gunatillake, Carnew and Akçelic (2000), and Koorey, Farrelly, Mitchell and Nicholson (1999), although these are in contexts not necessarily applicable to the A9.

Gunatillake et al. (2000) measured self-rated levels of frustration in response to a variety of urban video-filmed traffic situations in Australia. They found that frustration did vary with driving situations ('slow travel', such as congestion, being the main situation that led to a marked increase in frustration) but that there was little increase in frustration over time. Frustration ratings for the various driving situations were incorporated into a model (the Traffic Frustration Index or TFI) which was then validated on a variety of additional routes and times of day. Gunatillake et al. concluded that the TFI did a reasonable job of modelling driver frustration, but that it did not add much (if anything) beyond what could be achieved simply by measuring travel speed.

Koorey et al. (1999) used willingness to pay techniques to calculate an economic value for reduced frustration accruing from the provision of passing places on roads in New Zealand. They concluded that a value of NZ$0.035 (per vehicle per kilometre of passing opportunity) was robust and could be included in models along with the values for safety and journey time.

Both of these studies (albeit in different driving contexts to the A9) show that it is possible to measure frustration directly (in these cases using self-report survey techniques) and to consider it in road design and traffic modelling.

Grayson et al. nevertheless concluded that evidence focusing on frustration and overtaking behaviour directly is sparse. Only one study was found that directly addressed the issue. Kaub (1990) examined the effect of traffic flow on overtaking behaviour on a road in the United States, and found that as traffic flow went up, drivers were prepared to accept more risk in terms of the overtaking manoeuvres they attempted. This study demonstrates the potential for overtaking propensity to vary with traffic conditions believed to impact on frustration. Other studies using simulation (e.g. Pollatschek & Polus, 2005) have supported the general assertion that delays can lead to an increase the level of risk that at least some drivers are willing to accept in their overtaking decisions.

1.2 Appraisal and the A9 Dualling Programme

A common transport planning objective of projects is to reduce driver stress or frustration. Within Scottish Transport Appraisal Guidance (STAG) and Web-based Transport Appraisal Guidance (WebTAG) there is currently no methodology to quantify driver frustration. Transport Scotland is currently progressing the A9 Dualling Programme between Perth to Inverness to upgrade sections of single carriageway to dual carriageway. An objective of the A9 Dualling Programme is, ‘to improve safety for motorised and non-motorised users by reducing (i) accident severity and (ii) reducing driver stress.’ In order to be able to accurately value the benefits of reducing driver frustration and thus stress Transport Scotland commissioned two research studies on the topic. These initial studies are intended to form the basis for further research by Transport Scotland to develop guidance for the assessment of Driver Frustration within STAG.

2 This research

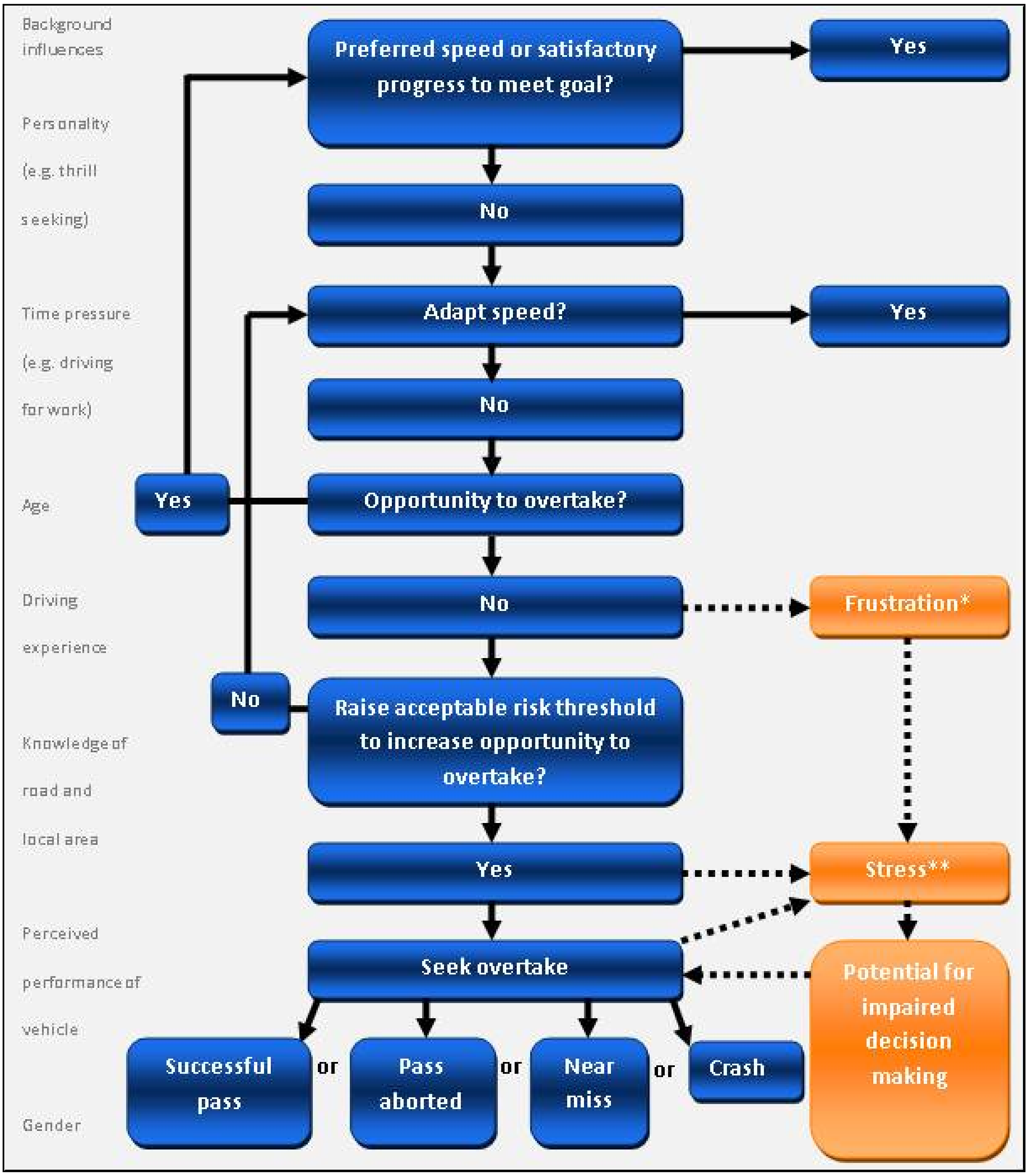
Grayson et al. (In press) suggest that little is known from empirical data on what variables impact on frustration and overtaking behaviour. Drawing largely on what is known from psychology, Grayson et al. (In press) propose a simple theoretical model designed to explain the processes underlying frustration and overtaking. The model (see Figure 1) is intended as a framework in which to think about the link between frustration and overtaking, incorporating the various other factors that are likely to play a role in determining whether or not a driver feels frustrated, and whether or not they decide to overtake in a given situation.

The study reported here builds on the Grayson et al. (In press) review; it directly examines the impact on self-reported frustration and overtaking intentions of various parts of the frustration model (specifically time pressure, and time behind a platoon) as well as factors associated with traffic that are known to be relevant on the A9 (specifically length of platoon, proportion of Heavy Goods Vehicles (HGVs), speed, and opportunities for overtaking).

The primary aim of the study reported here was to develop a better understanding of the impact of these situational variables on levels of frustration reported by drivers. The relationship between frustration and likelihood of overtaking was also explored.

An experimental study of frustration was designed and carried out to achieve this aim while a concurrent Stated Preference (SP) survey quantitatively appraised the value of frustration.

The purpose of the SP was to attempt to quantify the value that drivers place on frustration in order to provide relative values of time with reference to the A9 Dualling programme. The value that drivers place on travel time is influenced by travel conditions. For example, pleasant driving conditions have a lower perceived value of time associated than unpleasant driving conditions (Wardman & Ibanez, 2012). The value that drivers place on time spent travelling can be taken as a proxy for the levels of driver frustration.



*refers to (by definition) the act of being frustrated from travelling at the desired speed by a lack of an appropriate overtaking opportunity

**refers to a set of internal states including possibly frustration itself (arising from the act of being blocked) and others such as increased mental workload associated with planning or attempting more risky overtakes

Figure 1: A model of frustration and overtaking (reproduced from Grayson et al., In press)

3 Method

3.1 Experimental design

The single between participants independent variable was time pressure (two levels – 'time pressure' and 'no time pressure'). Within participants independent variables within the main analysis all had two levels; they were:

- length of platoon ('two vehicles' and 'ten vehicles')
- proportion of HGVs in platoon ('none' or '50%')
- speed ('40mph' and '56mph')
- road type ('single carriageway' and 'dual carriageway')
- oncoming traffic ('some' and 'none')

Additionally, the effect of the within-participants variable 'length of time behind platoon' ('5', '10', '15' and '20' minutes) was examined using a single video clip played multiple times with different instructions.

The key dependent variables (scored from 0 to 120 on a line scale) were level of frustration and likelihood of overtaking.

Thirty-six video clips were generated using TRL's DigiSim car simulator software. Thirty two of these clips covered all combinations of the variables length of platoon, proportion of HGVs in platoon, speed, road type, and other traffic (2 x 2 x 2 x 2 x 2 = 32), and were presented once each in the main part of the study. The other four were clips designed to allow participants practice at the task before the main part of the study, and also collected participants' self-reported speed intentions for single and dual carriageway roads; these clips showed the single and dual carriageway roads used in other clips, at 40mph and 56mph, but with no other traffic at all

One clip was played four additional times with different instructions (length of time behind a platoon) resulting in a total of 40 clips being presented to participants.

A questionnaire was used to collect data on the dependent variables for the various clips, along with demographic data and information regarding driving experience, and responses to the Driver Attitude Questionnaire (DAQ) which measures attitudes towards speeding, overtaking and close following and drink driving (Parker, Stradling & Manstead, 1996).

3.2 Stated preference design

The SP was designed to be broadly consistent with the experimental study and therefore used complementary independent variables, these were:

- **Speed:** this was the desired speed on the free flow route (assumed to be 60mph), but was constrained to be below this on the congested route.
- **Platoon type and length*:*** this was the composition of the platoon of vehicles directly in front of the respondent's vehicle. This was described in terms of the number of cars and HGVs in the platoon ahead on the congested route. There was no platoon on the free flow route.
- **Oncoming Traffic*:*** either there was oncoming traffic or not.
- **Journey time*:*** the journey time for part of the respondents' journey using each route. The journey time on the free flow route was longer than the journey time on the congested route because it is longer in distance. On the congested route this was the time spent behind a platoon.

Each variable was represented by different values or levels. In estimating a choice model of this type it is important that the independent variables are not correlated with each other as this so called 'multicollinearity' can cause statistical estimation problems. An 'orthogonal' design was used (this ensures that there were no correlations between the different independent variables and levels).

3.3 Participants

A total of 183 participants volunteered to participate in the study. Participants completed the study in groups of between 2 and 14. By virtue of the session they signed up for, 99 of these were allocated to the 'time pressure' group and the remaining 84 were allocated to the 'no time pressure' group. Due to incomplete responses, two participants from the ‘time pressure’ group and one participant from the ‘no time pressure’ group were excluded from the analysis.

In each of the two groups, the sample was matched as closely as possible to licence holders in the UK, based on 2011 data supplied by the DVLA. To be eligible to take part, participants needed to hold a full UK driving licence.

Participants were recruited from around Perth and Inverness. Participants were given £20 for taking part in the study, to cover travel expenses and time.

3.4 Procedure

Participants were given a short description of the study. Each participant was told that they would be shown simulated clips of driving situations, and that they would then be asked to answer questions about how they think they would feel if driving in the situation depicted. Participants then each completed a form giving their informed consent to take part in the study.

When all participants had consented, the instructions for the study were read out by the experimenter, and the clips were played. The video was paused after each clip if necessary to allow all participants time to complete the questions for that clip.

For all parts, those participants in the ‘No time pressure’ group were told that they were under no particular time pressure to be at their destination, while those in the ‘time pressure’ group were told to imagine that they were under time pressure as they were running late for an appointment. This was the only difference in instructions between the two groups.

After completion of the experiment, participants were asked to complete a short survey of demographic data, driving experience and the DAQ. Participants then completed the SP survey.

The layout of the SP survey is shown in Figure 2. The graphics which were used to generate a visual impression of the different options were provided by TRL from the video simulations. A full written description of the scenario was also given.

Option	Route A	Route B
A4		
Ahead	Nothing	6 Cars 3 Lorries
Oncoming Traffic	No	Yes
Speed	At desired speed 60mph	Constrained to 50 mph
Journey Time (mins)	15	8
I Choose (circle A or B)	A	B

Figure 2: Example SP scenario

Each respondent completed a questionnaire which included an introduction, an example and nine different SP scenarios.

Respondents were asked to say which alternative route they would choose given the scenarios presented. No explicit mention was made of overtaking. Respondents were told to make a choice on the basis of the information shown. So in the above example if they chose Option A their journey time would be 15 minutes and their speed would be 60mph. If they chose Option B their journey time would be 8 minutes, they would travel at 50 mph, would be following a platoon of traffic made up of 6 cars and 3 lorries, and there would be oncoming traffic for this length of time.

4 Results

4.1 The participant groups

Independent samples t-tests confirmed that the two groups did not differ significantly on mean age, mean number of years holding a driving licence, mean engine size of vehicle, mean annual mileage, and mean frequency of driving on the A9. Finally, independent samples t-tests showed that the two groups did not differ on any of the DAQ subscales (attitudes towards speeding, risky overtaking, close-following, and drink-driving), nor on the mean speeds given to the four baseline clips shown at the beginning of the study.

Taken together, the sample characteristics data suggest that the two groups did not differ *a priori* on any measures that might be expected to influence their responses independently of the time pressure instructions they received.

4.2 Experimental results

4.2.1 Frustration on single carriageway roads

The frustration data for single carriageway roads are shown in Figure 3. A five-way mixed ANOVA revealed significant main effects of speed and platoon length, $p<.001$ in both cases. The interaction between oncoming traffic and time pressure was also significant ($p=.006$), as was the three-way interaction between speed, platoon length and time pressure ($p=.024$).

Taken together, the analysis suggests that on single carriageway roads, speed and platoon length have a clear impact on self-reported frustration. The large effect of speed is easily observed in comparing the right and left groups of bars in Figure 3; lower speeds of progress clearly lead to higher frustration levels. A small but noticeable effect of platoon length can also be seen in Figure 3 by comparing the heights of the rightmost blue bars to the leftmost blue bars, and carrying out a similar comparison with the orange bars; in general the platoon length with ten vehicles gives rise to higher levels of frustration.

The effect of time pressure on frustration is more nuanced and cannot be easily determined by the naked eye. It would appear that being under time pressure (‘TP’ bars in Figure 3 increase frustration differently depending on speed and platoon length; for 40mph clips, TP seems to increase frustration more for the smaller platoon length, while for the 56mph clips the TP effect seems more pronounced for the longer platoons.

4.2.2 Intention to overtake on single carriageway roads

For overtaking intention data on single carriageway roads the five-way mixed ANOVA revealed significant main effects of speed, platoon length and oncoming traffic ($p<.001$ in all cases), and significant interactions between speed and platoon length, and speed and oncoming traffic ($p<.001$ in both cases).

Although the data suggest large effects of some individual variables, the interaction terms suggest that the picture is not straightforward, as seen in Figure 4. Lower speeds seem to be associated with a greater self-reported intention to overtake, as do shorter platoons. The presence of oncoming traffic seems in most cases to mediate these effects however; speed seems to have a stronger effect on intention to overtake when there is a smaller platoon, and no oncoming traffic.

Time pressure had no statistically significant effect on overtaking intentions in the single carriageway clips.

4.2.3 Frustration on dual carriageway roads

For frustration data on dual carriageway roads the five-way mixed ANOVA revealed significant main effects of speed and platoon length ($p<.001$ in both cases) and of HGV% ($p=.034$). In addition the interaction between platoon length and HGV% was significant ($p=.034$) as was the three-way interaction between speed, platoon and time pressure ($p=.001$).

As with the single carriageway data there is a clear effect of speed on frustration, such that lower speed is associated with higher self-reported frustration.

The effect of HGV% seems to be such that a higher % of HGVs is associated with greater frustration only in the longer platoons, but it is not a large effect.

The effect of time pressure on frustration is similar to that seen in the single carriageway clips. It would appear that being under time pressure increases frustration differently depending on speed and platoon length; for the 56mph clips the time pressure effect seems more pronounced for the longer platoons, while there is no clear pattern for the 40mph clips.

4.2.4 Intention to overtake on dual carriageway roads

For overtaking intention data on dual carriageway roads the five-way mixed ANOVA revealed significant main effects of speed and platoon length ($p<.001$ in both cases), and of HGV% ($p=.018$). In addition the interaction between speed and platoon length was significant ($p=.041$).

Lower speeds are associated with a greater intention to overtake, although the difference does not seem as pronounced as in the single carriageway data, presumably because even with the higher speed clips overtaking can be done safely on dual carriageways, and participants' intentions are higher in this condition than in the single carriageway case.

Shorter platoons also seem to be associated with higher likelihood of overtaking, and again this effect seems to be more prevalent at lower speeds.

A higher % of HGVs seems to be associated with a higher likelihood of overtaking, but the effect is not easily noticed in the data.

Time pressure had no statistically significant effect on overtaking intentions in the dual carriageway clips.

4.2.5 The relationship between frustration and overtaking

The correlation coefficient between frustration and overtaking is 0.16, which can be described as a weak correlation (albeit statistically significant due to the large sample). This finding supports the other data in showing that frustration and overtaking are not inextricably linked; if they were we would expect to see similar effects on frustration and overtaking of the other variables studied, and we would expect to see a stronger correlation between the two variables.

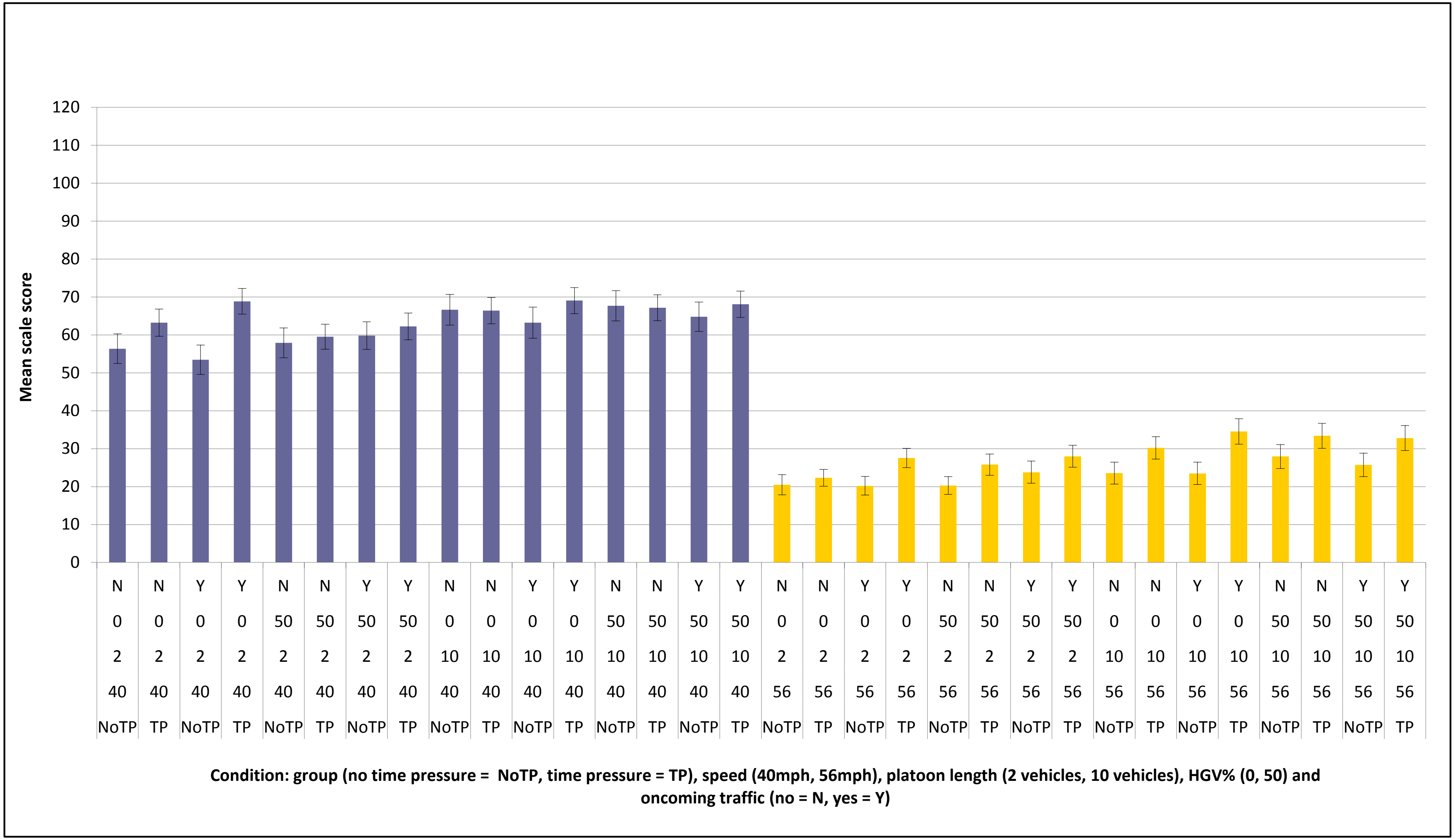


Figure 3: Mean frustration by condition on single carriageway roads (blue bars = 40mph, yellow bars = 56mph)

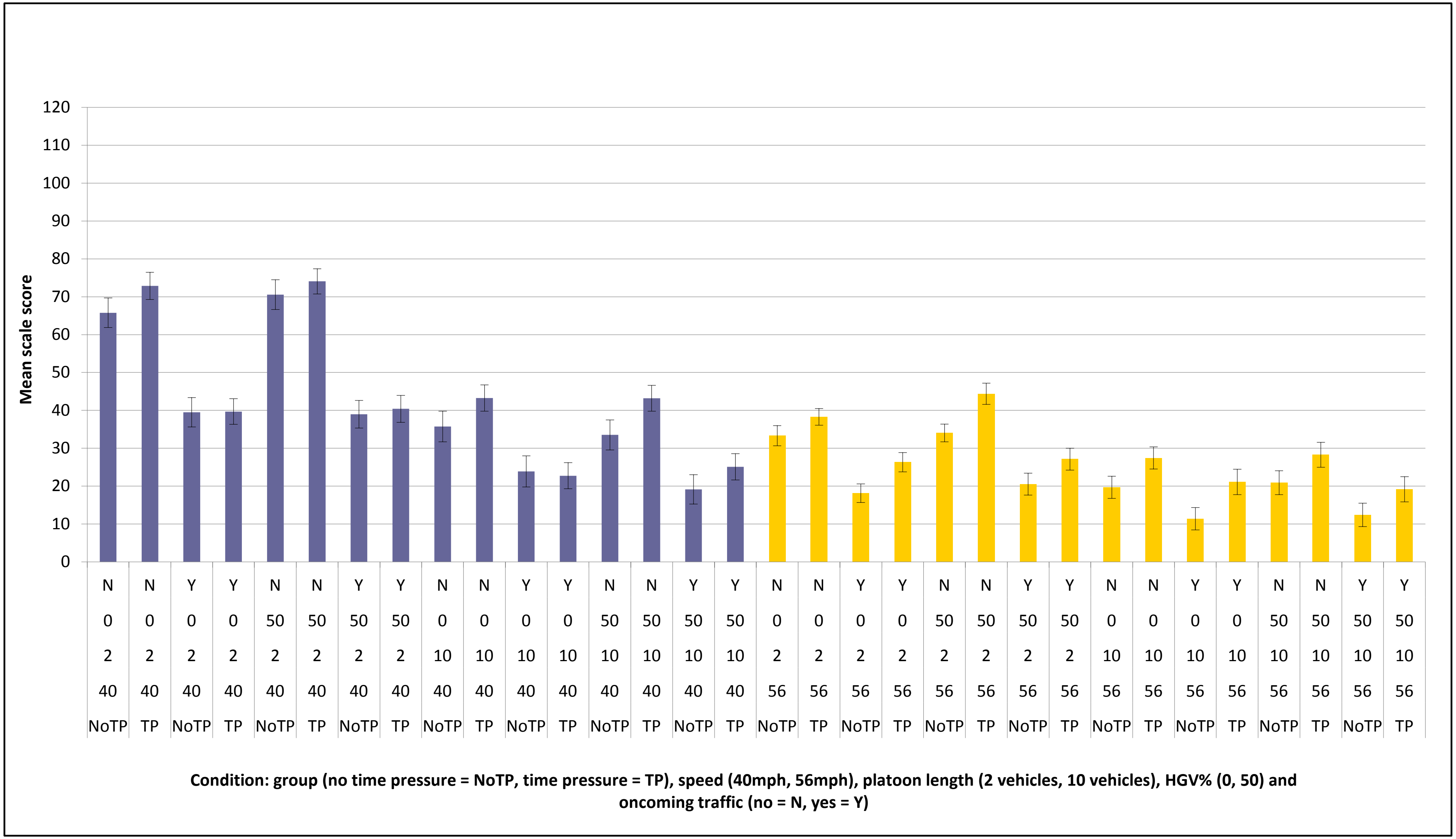


Figure 4: Mean overtaking intention by condition on single carriageway roads (blue bars = 40mph, yellow bars = 56mph)

4.2.6 Time behind a platoon

A two-way mixed ANOVA revealed a significant effect of time behind platoon (P<.001). As time behind platoon increases, so does self-reported frustration (see Figure 5). The effect of time pressure was non-significant.

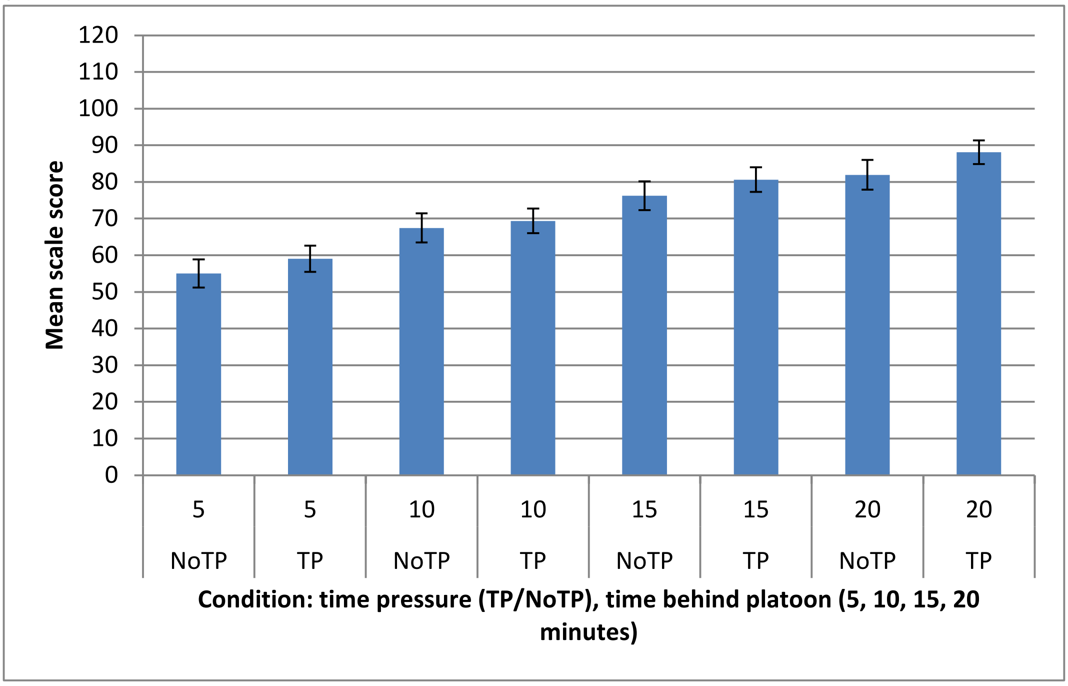


Figure 5: Mean frustration by time behind platoon and group (TP=time pressure; NoTP=No time pressure)

A two-way mixed ANOVA revealed a significant effect of time behind platoon (P<.001). As time behind platoon increases, so does self-reported intention to overtake (see Figure 6). The effect of time pressure was non-significant.

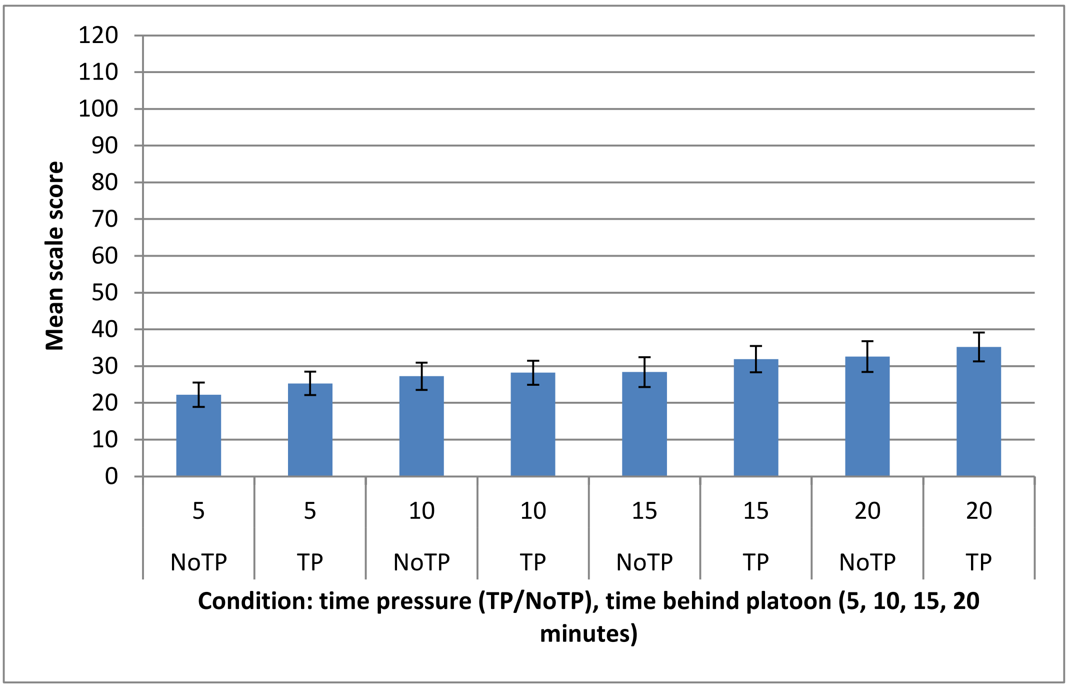


Figure 6: Mean overtaking intention by time behind platoon and group (TP=time pressure; NoTP=No time pressure)

4.3 Stated preference results

The SP modelling exercise used the statistical analysis package Biogeme (Bierlaire,2003) to estimate a standard binary logit model from which the model parameters associated with the utility functions described below and goodness of fit statistics were derived.

Modelling estimated a utility function for each route (A and B) based on the variables shown to respondents in the SP exercise. A utility function describes how important different variables are in determining overall utility and hence choice, since it is assumed that the alternative with the highest utility (lowest disutility) will be chosen. The utility functions estimated for each route are presented below. These are linear additive in nature with parameter estimates that are 'best fit' to the choices made in the survey.

$$U_a = \text{b1}*TIME_a$$

$$U_b = ASC + \text{b1}*TIME_b + \text{b2}*(TIME_b*SPEEDDIFF) + \text{b3}*(TIME_b*CARS) + \text{b4}*(TIME_b*HGVS) + \text{b5}*(TIME_b*ONCOMTRAF)$$

where:
$\mathbf{U_a}$**:** Total Utility for Route A;
$\mathbf{U_b}$**:** Total Utility for Route B;
$\mathbf{TIME_a}$**:** journey time on Route A;
$\mathbf{TIME_b}$**:** journey time on Route B;
SPEEDDIFF: difference between the desired free flow speed presented on route A (60mph) and the speed shown on route B;
CARS: number of cars in the platoon ahead on Route B;
HGVS: number of HGVs in the platoon ahead on Route B;
QUEUE: number of vehicles (cars and HGVs) in the platoon ahead on Route B;
ONCOMTRAF: described whether there was oncoming traffic or not on Route B;
ASC: route specific constant which measures the impact of other variables not included in the model; and
b1, b2, b3, b4 and b5: parameters to be estimated.
The parameters b1 – b5 measure the impact of a unit change in the variable in question on utility.

A journey time variable ($TIME$) was estimated, which gives the base time multiplier. The parameter b1 measures how much utility changes when the time on Route A or Route B changes by one unit (one minute).

The other parameters were estimated for interaction variables. Parameters b2 to b5 measure the impact of a unit change of the non-time variable on the time variable. This way it is possible to see how the time variable changes in relation to these other variables.

A number of models were estimated; the preferred final model is presented here. An important measure of quality of a SP survey is the degree to which respondents change their choice between the options (A or B) presented through the SP exercise. If they vary the option chosen in the experiment they are called 'traders'. Respondents who choose the same option throughout are called 'non traders'. Approximately 30% of the sample were non-traders. The final model below was estimated on the whole data set with non-traders included.

Table 1: Overall Preferred Model (Non-traders included)

Name	*Value*	*T Ratio*
(b2)$\boldsymbol{TIME}$ * ***SPEEDDIFF***	-0.00760	9.85
(b4)$\boldsymbol{TIME}$ * ***HGVS***	-0.00900	2.77
(b5)$\boldsymbol{TIME}$ * ***ONCOMTRAF***	-0.02480	2.78
(b1) $\boldsymbol{TIME}$	-0.18900	7.84
Number of observations:	1616	
Number of individuals:	180	
Rho-square:	0.187	
Adjusted rho-square:	0.183	

In estimating this model, parameters were estimated for:

- $TIME$*CARS (b3) which measured the impact of the number of cars in the platoon on the value of time; and
- A route constant ASC which measures the impact of influences not specified in the model were estimated but their T Ratios were less than 1.96 so were dropped from the model.

In this overall preferred model all the T Ratios are much greater than 1.96 giving confidence that the parameter values are reliable. The rho squared statistic is also high (0.187) so the model can be viewed as being robust.

This model suggests that route choice (and hence drivers' frustration) and their Value of Time is influenced by:

- Being unable to drive at desired speed;
- Presence of oncoming traffic; and
- Number of HGVs in the platoon ahead (the number of cars in the platoon was not found to be important based on SP modelling alone).

4.4 Comparison of results from SP and experimental survey

This study involved two methods for exploring driver frustration: an experimental approach and secondly an SP experiment where respondents were asked to trade off different driving conditions.

The experimental study provides a direct measure of drivers' self-reported frustration, whereas the SP study provides relative values of time for different driving conditions, which is taken as a proxy for frustration level.

For the application of the SP a base time multiplier equal to one was assumed if travelling at desired speed with no platoon of traffic ahead and no oncoming traffic and this was adjusted to take into account the impact of travelling below desired speed, number of HGVs in the platoon ahead and whether there was oncoming traffic. The impacts of these variables on the time multiplier are shown in Table 2.

Table 2: SP impact on time multiplier (proxy for frustration level)

Variable	**Impact on Time Multiplier**
Not being able to drive at desired speed	Increases by 0.0402 for each mph below desired speed
Whether there is oncoming traffic	Increases by 1.13 if oncoming traffic
The number of HGVs in the platoon ahead	Increases by 0.0476 for each HGV in the platoon of traffic ahead

The data suggest good correspondence between the two indices. This is confirmed by the Pearson correlation coefficient of 0.975. This is very high and is significant at the 0.01 level (2-tailed).
The Experimental frustration index is generally higher than the SP Frustration Index, particularly when the speed is lower at 40mph; this may be due to scaling which makes it difficult to compare the absolute values produced by the two approaches. Nevertheless, the high correlation between them is encouraging, particularly as the methodologies used to derive these indices were completely different.

5 Conclusions

The current study sought to understand and quantify the impact of several situational variables (all associated with driving in platoons of vehicles) on levels of self-reported frustration and intention to overtake. This was achieved through two complementary methodologies:

1. An experimental study
2. An SP survey

The experimental study utilised specially designed simulated video clips depicting a driver's-eye viewpoint of a driving situation. These clips varied by following a platoon of vehicles that varied in size and the proportion of HGVs present, speed of progress, road type, and the presence or absence of oncoming traffic. In addition some participants were instructed to imagine that they were under time pressure, while others were told to imagine that they were under no time pressure.
The key findings from the experimental study are summarised in Table 3 where the variables studied are compared for their effect.

Table 3: Summary of key findings

Variables being compared			Key finding
Speed	**and**	**Frustration**	**Speed had a consistent effect on frustration.** The lower speed (40mph) was associated with higher self-rated frustration than the higher speed (56mph). This was true for single and dual carriageway clips.
Speed	**and**	**Intention to overtake**	**Drivers' intention to overtake was higher at the lower speed.** The lower speed (40mph) was associated with greater intention to overtake than the higher speed (56mph). This was true for single and dual carriageway clips.
Length of platoon	**and**	**Frustration**	**Frustration was higher for the longer platoon.** The longer platoon (10 vehicles) was associated with higher frustration than the shorter platoon (2 vehicles). This was true for single and dual carriageway clips.
Length of platoon	**and**	**Intention to overtake**	**Drivers' intention to overtake was higher for shorter platoons.** This was true for single and dual carriageway clips.
Speed & Length of platoon	**and**	**Frustration & Intention to overtake**	**The effects of speed and platoon length were not necessarily uniform and demonstrate the importance of the context.** Although drivers become more frustrated as platoon lengths increase and as speed decreases, they appear to control their overtaking intentions dependent on the driving situation, and are not solely responsive to their level of frustration.
Frustration	**and**	**Intention to overtake**	**Frustration and overtaking behaviour overall were not highly correlated.**
Length of time behind a platoon	**and**	**Frustration & Intention to overtake**	**As the length of time spent behind a platoon increases, driver ratings of frustration and intention to overtake increase, at similar rates.** A short time period behind a platoon (i.e. 5 minutes) was rated similarly to having just arrived at the platoon. However, as time

			behind the platoon increased to 10, 15 and 20 minutes, ratings of frustration and intention to overtake increased.
Single carriageway	**and**	**Dual carriageway**	**Single carriageway clips gave rise to significantly higher frustration ratings than dual carriageway clips.**
Time pressure	**and**	**Frustration**	**Time pressure increased frustration but only in some circumstances.** On single carriageway clips at 40mph, time pressure resulted in increased frustration when behind the shorter platoon. However, when travelling at 56mph the most obvious increase in frustration when under time pressure was for the longer platoon. On dual carriageway roads the pattern is similar although not as pronounced.
Time pressure	**and**	**Intention to overtake**	**Time pressure had no detectable effect on intention to overtake.** This was true on single and dual carriageway roads.

The SP results suggest that drivers' frustration is influenced by:

- Being unable to drive at one's desired speed;
- The presence of oncoming traffic; and
- The number of HGVs in the platoon ahead

All methodologies have strengths and weaknesses and this study was no different. Cross-validation of the results from one methodology to the other provides some confidence in the results reported. Nevertheless, the design of both the experimental and SP studies was novel and some variables may not have had the impact that might be expected, namely time pressure. Even though both methods failed to find a strong overall effect of time pressure, it is quite possible that the manipulation of this variable was not sufficiently strong to result in differences on the measured outcome variables. Future studies should consider how the manipulation of time pressure might be strengthened. A further weakness is that the study relies on self-reported responses to simulated video clips and survey materials. Previous studies have shown that studying measures in response to stimuli of simulated driving scenarios is a valid approach to establish relative changes; nonetheless the extent to which findings such as these can be used to estimate specific, absolute changes in the outcome variables of interest will be strengthened by future studies that use real world data (Mullen, Charlton, Devlin & Bédard, 2011).

As a whole, the findings show that the links between traffic variables such as speed and platoon length, and behaviourally-relevant variables such as frustration and overtaking intentions, are not simple.

The results of this study suggest that if the speed limit for heavy goods vehicles in excess of 7.5 tonnes maximum laden weight was raised from 40mph to 50mph, it is likely to result in a reduction in frustration, but a consequent reduction in drivers' intention to overtake when held up by a platoon cannot be predicted from these results.

The results of this study also suggest that the impact of upgrading the route to dual carriageway is likely to reduce frustration. Any reduction in frustration will probably be associated with the impact of the road type, the opportunity for safe overtaking to make progress, and the increase in traffic flow and journey speed.

The relative benefits of changing speeds, the number and nature of overtakes, and drivers' experience when using the A9 will need to be monitored in detail as the changes are implemented. The current work provides a starting point for this revealing a number of complexities in the relationships between the variables under investigation.

Future work may seek to validate these results using real-world data to inform future evaluation and guidance, and by applying the work to other routes.

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