# isa - UK

*intelligent speed adaptation*

Results of Field Trial 2

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# EXECUTIVE SUMMARY

## Introduction

This report documents the second of a series of four field trials with Intelligent Speed Adaptation, i.e. a system in which the vehicle "knows" the speed limit and that knowledge can be used to constrain the maximum speed at which a vehicle can travel. The main focus of the trials is on driver behaviour when using ISA over a relatively long period, i.e. four months of driving. The ISA driving is compared with a pre period and an after period of driving without ISA. Both the pre and after periods are one month in duration, giving a total trial duration of six months. The experimental design allows comparison of driving without ISA in the pre period with driving with ISA active in the "system" period. It also allows comparison of the system period with the after period in order to reveal whether there any carry-over effects of the ISA driving on subsequent behaviour. The results presented here should not way be construed as predicting the results of the other field trials

This trial, in contrast with the first trial with private motorists, was carried out in a fleet context, using employees of Leeds City Council. Twenty motorists who do most of their driving in the Leeds area were recruited. Each of them was given the use of a modified vehicle for the trial period. These vehicles behave like "normal" cars apart from the ISA feature. Data was logged automatically on a hard drive that cannot be accessed by the user, and summary data was collected after each trip through a GSM (mobile phone) link. The ISA was overridable by the drivers, by mean of a button on the steering wheel or a kick-down on the throttle pedal. The speed limit map covered the Leeds area and the national trunk road network. The intention was to give drivers ISA support for almost all their regular driving during the ISA-active phase.

## Method

The vehicles and the in-vehicle map used for this trial were the same as those used in Trial 1. The vehicles were refurbished between the trials and some small modifications, principally to electrical connection, made to increase reliability.

Given the age distribution in the departments of Leeds City Council from which the drivers were recruited, it was not possible to select equal numbers of males and females. Seventeen males (age range 23–59 years) and three females (age range 35–45 years) took part in the trial. The selected participants tended to:

- Have an average annual mileage exceeding 10,000 miles
- Undertake at least 80% of their driving within the area of Leeds Metropolitan District
- Demonstrate average mileage proportions by weekday/weekend split
- Demonstrate average exposure rates to different road types

Seven of the drivers lived outside the Leeds area, but did most of their driving within it.

In Trial 1, participants were divided into groups based on their prior attitudes to ISA, but the initial grouping by attitudes did not provide homogeneous behaviour. A decision was therefore made to select participants as 'intenders' and 'non-intenders' based on their intention to exceed the speed limit.

The characteristics of the participants are shown in Table 1.

**Table 1: Characteristics of Trial 2 participants**

| *Gender* | *Age* | *Intention to Speed* | *Number* |
|---|---|---|---|
| Male | 23–39 | Intender | 4 |
| Male | 23–39 | Non-Intender | 3 |
| Male | 40–60 | Intender | 6 |
| Male | 40–60 | Non-Intender | 4 |
| Female | 23–39 | Intender | 1 |
| Female | 23–39 | Non-Intender | 1 |
| Female | 40–60 | Intender | 1 |

## Major Results

### *Attitudinal changes*

Data was generally gathered in the pre-ISA phase (Phase 1), during ISA operation (Phase 2) and after ISA was switched off (Phase 3). Usage of Intelligent Speed Adaptation had generally positive effects in terms of attitudes. Intention to speed was generally negative, meaning that respondents generally did not intend to speed. Intention to speed on urban roads was reduced after the ISA was switched on, and the reduction continued into Phase 3 when the ISA was once again disabled (see Figure 5). Attitudes to speeding on urban roads became slightly more negative with ISA and this effect also persisted after the ISA was disabled. Attitudes to speeding on motorways and residential roads tended to become more positive with ISA, although as regards residential roads they were highly negative throughout. For urban roads, the system appears to have heightened drivers' awareness of the legal implications of speeding.

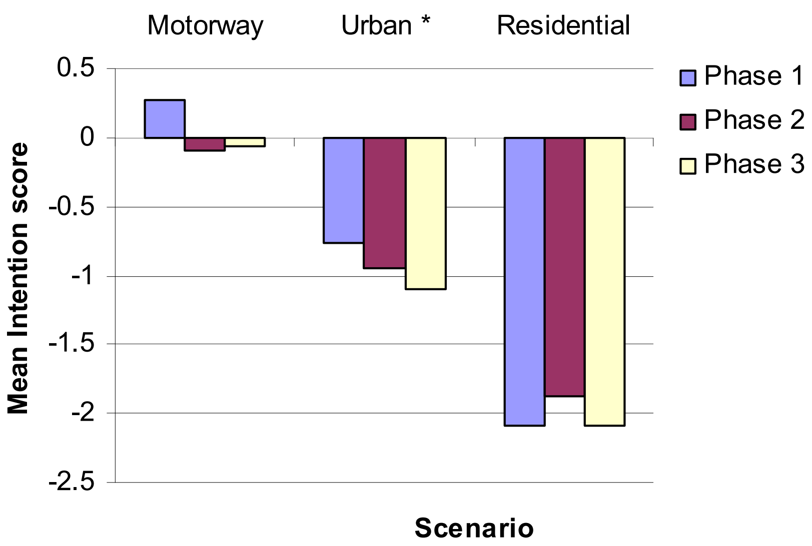


**Figure 5: Intention to speed**

Somewhat surprisingly, there was little change in drivers' perceived behavioural control. It had been anticipated that driving with the system would decrease drivers' perceptions of control, since the system was taking control over some aspects of speed choice.

Drivers' self-reported propensity to exceed the speed in the previous month, shown in Figure 6, decreased during Phase 2 on all the road categories. Self-reported speeding in Phase 3 increased but, apart from the motorway category, was still lower than that reported at Phase 1, suggesting that the effects of ISA may have been sustained even with unsupported driving.

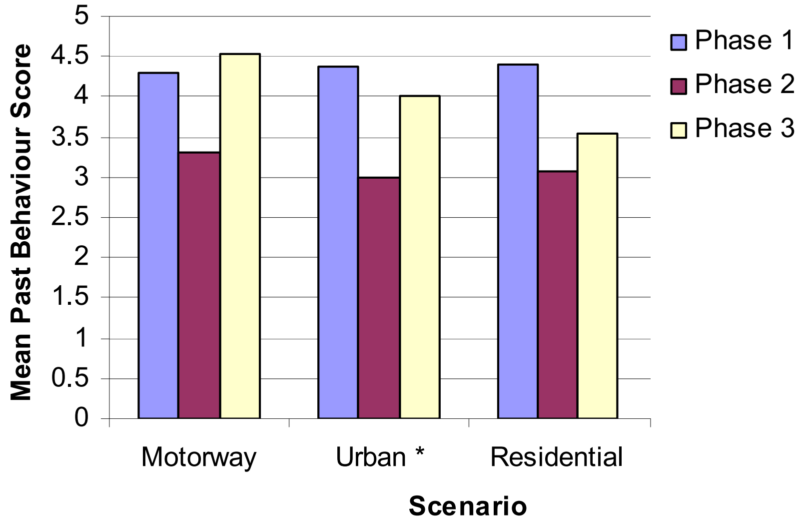


**Figure 6: Self-reported speeding**

Self-reported violations, errors and lapses all decreased with ISA and this effect persisted after the ISA was switched off. Acceptability of ISA was ascertained at four time points: in the pre-ISA phase, early in the ISA-enabled phase, late in the ISA-enabled phase, and after ISA was disabled (see Figure 7). The acceptability rating of the ISA system in terms of usefulness and satisfaction both improved over time. Usefulness may represent a social utility construct, whereas satisfaction has more to with fulfilment of personal goals. In the EVSC project, users' satisfaction ratings tended to go down once they used the ISA-equipped car. But in this trial satisfaction steadily improved over time after the enabling of ISA, going from slightly negative to slightly positive. It is quite encouraging that satisfaction was as its highest level after the system had been withdrawn. Usefulness similarly increased with experience of the system.

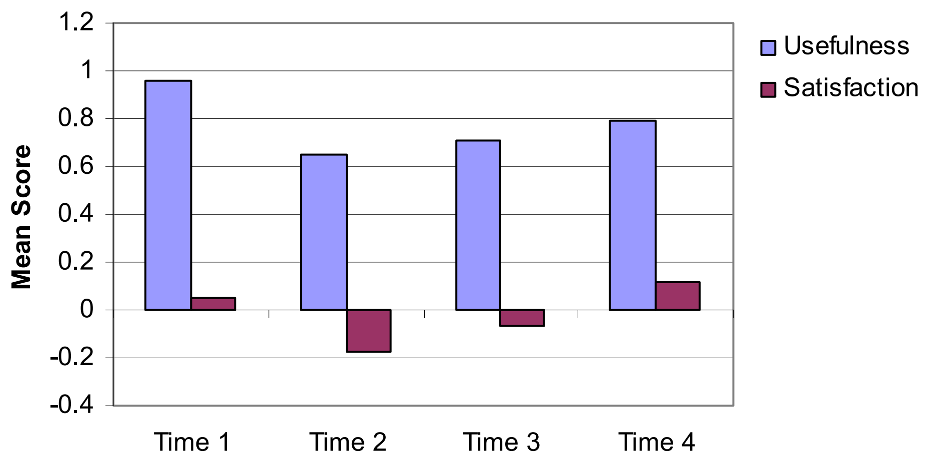


**Figure 7: Acceptability of ISA**

### Behavioural changes

The ISA system was observed to have a distinctive effect in terms of the transformation of the speed distribution across all speed zones. This means that speeds over the speed limit and in particular very high exceeding of the limit was curtailed. When ISA was switched on, a large proportion of the speed distribution initially spread over the speed limit was shifted to around or below the speed limit. This is illustrated in Figure 8 which shows the percentage of distance travelled on 30 mph roads which occurred in various parts of the speed distribution. It should be noted that the ISA system used in the trial did not cut off speed sharply at 30 mph; hence the increase in travel at speeds between 30 and 35 mph when ISA was enabled.

Analysis of various statistics related to speed (mean, 85th percentile, etc.) revealed a general 'V' shape across trial phases, i.e. the statistic goes down from Phase 1 to Phase 2, then up from Phase 2 to Phase 3. This pattern is especially prominent with respect to high percentiles of the speed distribution, which are strong indicators of speeding behaviour. ISA has not only diminished excessive speeding, but also led to a reduction in speed variation with positive implications for a reduction in accident occurrence. It was also generally the case that indicators of speed were lower in the last month than in the first month, i.e. ISA had a positive carry-over effect.

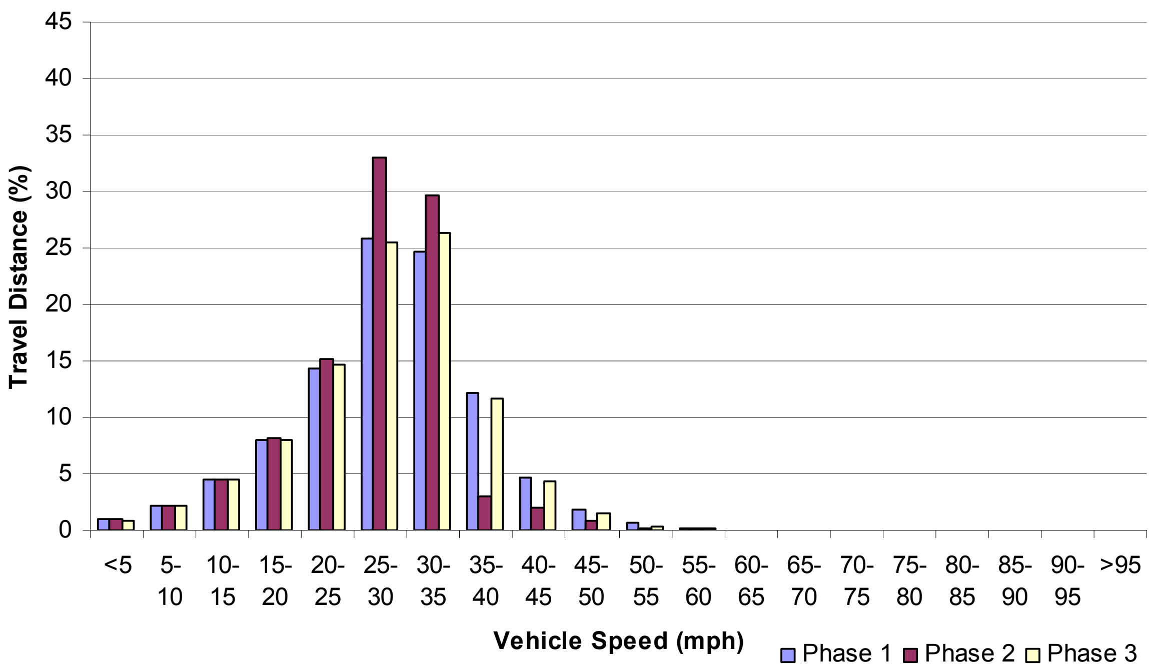


**Figure 8: Speed distribution by phase on 30 mph roads**

The use of an overridable ISA system also provides an opportunity to demonstrate potential resistance from the driving population against its implementation, based on true behaviour instead of opinion. ISA was overridden most often on 20 mph and 70 mph roads (see Figure 9). It should be noted that driving on 20 mph roads only accounted for 0.1% of total distance travelled in phase 2. In terms of demographic groups, the male-female distinction is not reliable because of the uneven number of participants (only three females). Young drivers overrode ISA more than older drivers, particularly on 30 mph (12.6% compared to 6.4%) and 70 mph roads (20.8% compared to 11.4%). And intenders overrode the system more frequently than non-intenders across all speed zones, apart from the 60 mph zone. The difference on the 70 mph roads was particularly marked: 19.1% compared to 8.1%. As with other safety systems (e.g. seatbelts), there is therefore a tendency for those who need it most to use it least. This suggests that there may be a role for incentives to keep ISA active and discouragement of overriding when ISA is deployed on a voluntary or fleet basis.

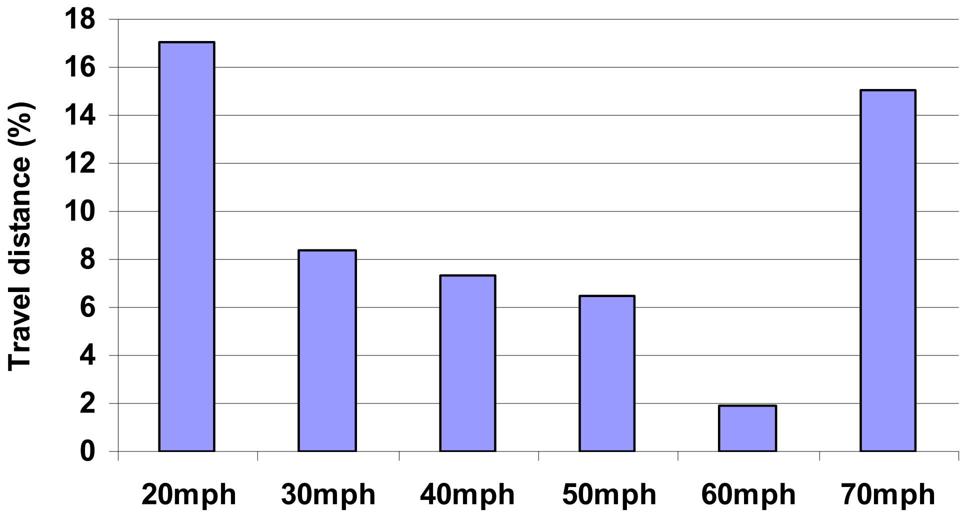


**Figure 9: Proportion of distance travelled with ISA when the system was overridden**

In spite these findings, ISA still had a positive impact on all groups, including young drivers and intenders to speed. In addition to improved speed limit compliance, ISA also contributes to diminished negative driving behaviour across all groups, as revealed by the observation drives.

The trial has also revealed that participants adapted their reference to chosen speed between trial phases. During Phase 1 and 3 when the ISA system was turned off, participants were observed to obey the speed limits with reference to speedometer reading. During Phase 2, participants were observed to rely on the ISA system (i.e. throttle cut-off) instead of the speedometer reading. This has implications because the design used here had the speedometer reading high but the ISA system using true speed, meaning that if drivers used the ISA system to regulate maximum speed that speed would be higher than when using the speedometer for the same purpose. The obvious solution is for the speedometer regulations to be changed so that they read accurately. In addition, the current design of the ISA system does not restrict vehicle speed to posted speed limits (i.e. the speed limits provided by the digital maps) to absolute precision. The throttle control permits vehicle speed to go somewhat over the speed limit, due to hysteresis in the ISA system response to driver throttle demand. If drivers relied on the system to keep them within the speed limit, they might actually be above the limit. This would need to be considered in setting standards for real-world ISA.

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# 1. INTRODUCTION

The ISA-UK project has as its major objective to investigate user behaviour with Intelligent Speed Adaptation (ISA) by means of set of field trials. Twenty identical vehicles have been converted with the capability to provide a voluntary (overridable) ISA system and to record data on each drive. Four successive trials are planned, each of six months duration. The four field trials are:

Trial 1: Leeds area with private motorists
Trial 2: Leeds area with fleet motorists
Trial 3: Leicestershire with private motorists
Trial 4: Leicestershire with fleet motorists

The Leeds trials are in a major urban area, although the speed limit data cover the whole of the Leeds Metropolitan District, which includes some outlying rural areas and villages. The selected Leicestershire area is mainly rural and small-town.

The trials are designed to be non-intrusive — the vehicles behave like "normal" cars apart from the ISA feature. Data is logged automatically, and summary data is collected after each trip through a GSM link. The ISA system designed for the four field trials is user overridable. The intention is to give drivers ISA support for almost all their regular driving.

The main focus of the trials is on driver behaviour when using ISA over a relatively long period, i.e. four months of driving. There is one-month driving without ISA functions before and after the four-month driving with ISA respectively. The inclusion of the post-ISA driving allows the investigation of any carry-over effects of the ISA intervention.

This report presents the results of Field Trial 2 and is structured into six chapters. The next chapter describes the design of the field trial, followed by analysis results of vehicle data, questionnaire data, and the observation drives. Finally, the sixth chapter summaries the findings and implications of the analysis results.

# 2. FIELD TRIAL METHODOLOGY

## 2.1 Introduction

The methodology for this trial was in line with the first trial (Lai et al, 2005), with a few minor revisions. A brief description of the methodology is presented in this chapter and relevant revisions are reported.

## 2.2 The vehicles

The ISA system was installed on a fleet of 20 Skoda Fabia Elegance 1.4 litre estate. The system consisted of two computers installed in the boot of the host vehicle (one to provide the information function, i.e. vehicle position and current speed limit, and the other to provide speed limiting and data recording), as well as additional hardware wired to the vehicle's fuel and brake systems, the instrument panel, and the steering wheel. The appearance of the ISA vehicles was as an ordinary Skoda Fabia.

The speed limit map installed on one of the computers in the vehicle's boot provided essential information for the ISA system to function correctly. There were a few speed limit changes within the Leeds Metropolitan area introduced by Leeds City Council when the first field trial was being carried out. These changes were subsequently reflected on the speed limit map used for this trial. A total of 721 links across 20-70 mph speed zones were updated with new speed limits, which was accounted for 1.7% of the total links on the digital speed limit map.

Apart from revised digital speed limits map, all vehicles were refurbished at the end of Trial 1, which included data backup, ISA function inspection (e.g. buttons and brake performance etc), and general vehicle inspection (e.g. tyre treads and fluid levels etc.). In addition, there were a few changes introduced to the software and hardware specifications during Trial 1 which remained effective throughout Trial 2. These revisions are given in Appendix A.

## 2.3 Trial design

The field trial comprised three distinct phases over 6-month duration, as illustrated in Figure 1. This structure was identical to Trial 1.

| **Phase 1** | **Phase 2** | | **Phase 3** |
|---|---|---|---|
| **ISA OFF** | **ISA ON** | | **ISA OFF** |
| 28 days | 28 days | 84 days | 28 days |

↑ Observation Drive 1 — ↑ Observation Drive 2 — ↑ Observation Drive 3 — ↑ Observation Drive 4

**Figure 1: The structure of the ISA field trial**

## 2.4 Participant recruitment

Seventeen males (age range 23-59 years, M = 41.59, SD = 12.72) and three females (age range 35-45 years, M = 39.67, SD = 5.03) took part in the trial. Participants were recruited from employees of Leeds City Council (LCC). Two information mornings were held at LCC's head office in order to recruit members of staff who worked together and regularly used their car as part of their work. It was initially intended that all participants would be recruited from the same department within the council, however due to low interest in the project, the sample was widened to other departments.

Two recruitment events and an intranet posting resulted in only 24 willing participants. Given such a low response it was extremely difficult to select on the agreed criteria specified in Lai et al (2005). The selection criteria relating to attitudes towards ISA were also eliminated following analysis of the first trial. The initial grouping by attitudes did not provide homogeneous behaviour. A decision was therefore made to regroup participants into 'intenders' and 'non-intenders' based on participants' intention to exceed the speed limit. This classification was regarded as more reliable than the original grouping method which was based on participants' attitudes towards a system with which they had no experience. The respondents were asked to complete a questionnaire that identified their general intentions to exceeding the speed limit on an urban road and motorway using the Theory of Planned Behaviour. Intentions were assessed by three items, e.g. 'I would intend to exceed the 70mph speed limit on a motorway', strongly disagree-strongly agree, scored −3 to +3. Participants were selected to reflect those who intended to speed (scores above 0) and those who did not (scores below 0).

By process of elimination, four participants with a low mileage, living outside the Leeds area were excluded. As can be seen in Table 1, the majority of the participants were male (due to small minority of women working within the transport department) with an almost even split of young and old participants.

**Table 1: Characteristics of Trial 2 sample**

| *Participant* | *Gender* | *Age* | *Exposure* | *History* | *Intention Group* |
|---|---|---|---|---|---|
| 1 | male | 23-39 | All participants will have reported average annual mileages of >10,000 miles. In addition, all will have a high proportion of their driving in the specified map area. | No history of driving convictions and no more that 2 (at-fault) accidents in 3 years. | intender |
| 2 | male | 23-39 | | | intender |
| 3 | male | 23-39 | | | intender |
| 4 | male | 23-39 | | | intender |
| 5 | male | 23-39 | | | non-intender |
| 6 | male | 23-39 | | | non-intender |
| 7 | male | 23-39 | | | non-intender |
| 8 | male | 40-60 | | | intender |
| 9 | male | 40-60 | | | intender |
| 10 | male | 40-60 | | | intender |
| 11 | male | 40-60 | | | intender |
| 12 | male | 40-60 | | | intender |
| 13 | male | 40-60 | | | intender |
| 14 | male | 40-60 | | | non-intender |
| 15 | male | 40-60 | | | non-intender |
| 16 | male | 40-60 | | | non-intender |
| 17 | male | 40-60 | | | non-intender |
| 18 | female | 23-39 | | | intender |
| 19 | female | 23-39 | | | non-intender |
| 20 | female | 40-60 | | | intender |

Although seven of our participants lived outside the Leeds area, the majority of their day to day driving was within our boundaries and experience within Field Trial 1 showed that several roads outside the digital map were covered using the trunk road and motorway speed limit information provided by Navteq.

Eleven of our participants worked together in the Middleton transport office, five worked within the city centre transport office, two worked within the Environmental health office and two participants worked within other council departments in the Leeds area. The idea that participants would interact daily with other ISA users was therefore achieved for 90% of the sample.

Respondents selected to take part in the trial were then required to sign an agreement (given in Appendix A) between the University of Leeds and themselves covering issues such as data collection, insurance claims and car maintenance procedures.

### 2.4.1 Demographic and driving characteristics

Several items sought information about key demographic and driving characteristics in order to give a brief overview of the sample.

**Table 2: Age by attitude group**

| | N | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| **Intenders** | 12 | 41.50 | 11.34 | 24 | 57 |
| **Non-Intenders** | 8 | 41.00 | 13.27 | 23 | 59 |

As can be seen in Table 2, it was difficult to recruit participants at the extremes of the age group ranges with the majority aged within the 30-50yr age bracket.

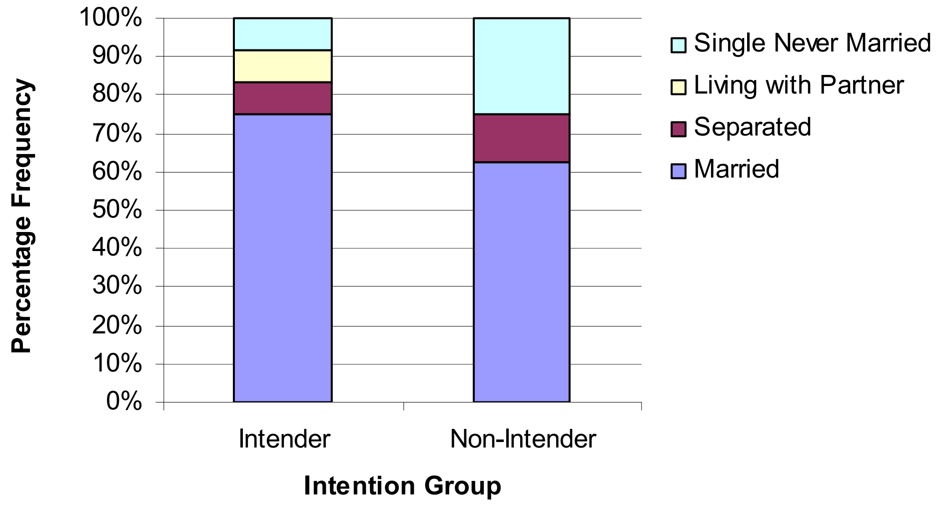



**Figure 2: Marital status by intention group**

Figure 2 shows little variation across the groups in terms of their marital status with 75% of the participants married or living with a partner. Thirty-five percent of the participants also had one or more children aged 18 or under living with them (see Figure 3). Non-intenders were less likely to have a child living at home.

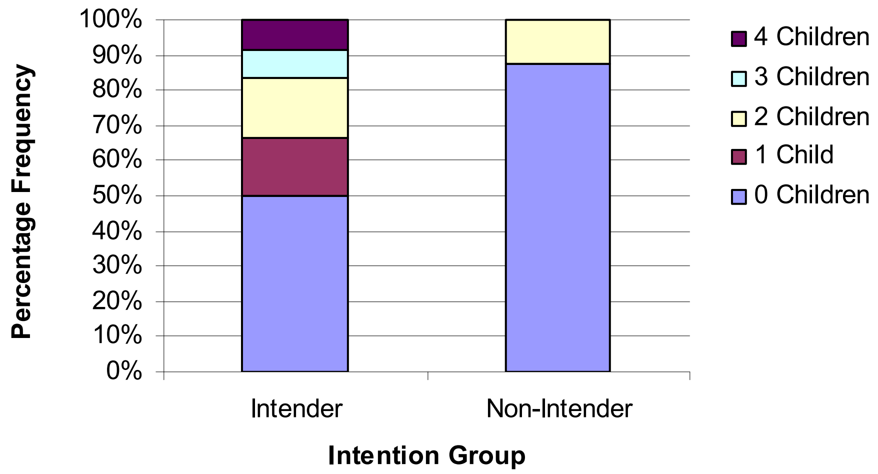



**Figure 3: Number of children (18yrs and under) living at home by intention group**

Given that the participants were recruited from council offices there was no variation across National Statistics Socio Economic classifications. All participants, except one (holding a lower supervisory and technical position) held managerial and professional positions.

Table 3 provides an overview of the participants' self reported mileage and trip frequency. As required the participants generally accrued an average annual mileage that exceeded 10,000 miles and spent at least 80% of their time driving within the Leeds area. Comparison across the groups revealed no differences.

**Table 3: Participants mileage and trip statistics**

| | Intenders | Non-Intenders |
|---|---|---|
| Leeds weekday mileage | 184.46 | 172.25 |
| Leeds weekend mileage | 44.92 | 58.50 |
| Leeds total weekly mileage | 229.38 | 230.75 |
| Leeds monthly mileage | 917.50 | 923.00 |
| Leeds annual mileage | 11927.50 | 11999.00 |
| Total annual mileage | 15145.00 | 15411.50 |
| % of driving in Leeds area | 78.83 | 78.88 |
| No. weekday trips | 24.83 | 23.00 |
| No. of w/end trips | 6.83 | 11.25 |
| Total weekly trips | 31.67 | 34.25 |

Three participants, all intenders, had received three points for speeding within the last five years. Six of the participants (3 intenders, 3 non-intenders) had been involved in an accident in the last 5 years. Two of the non-intenders had been involved in two accidents in the last five years.

## 2.5 Data collection

A wide range of data was collected during the trial, including objective measures recorded by the vehicle, and subjective measures obtained through questionnaires. These are specified in the following sections, followed by a description of the data management system.

### 2.5.1 Objective measures

Although the focus of this project is travelling speed and speed limits, many other parameters were recorded during the course of a trip, such as time stamps and coordinates etc, at 10 Hz (i.e. 10 records per second) by the data logging system installed in the vehicle. The purpose of recording coordinates was to enable replication of a trip should it be required at a later date. Many trip based parameters, for example trip length, trip duration and fuel usage, were also recorded by the vehicle's logging system.

### 2.5.2 Subjective measures

#### 2.5.2.1 General speeding and experience with system

Items sought information regarding participants' experience of the system including perceptions of the risk and frustration associated with driving under ISA control on certain roads.

#### 2.5.2.2 The Theory of Planned Behaviour

The TPB was applied to four risky driving behaviours. These behaviours were:

**Speeding on a motorway:** Imagine you are driving along a motorway. It is a fine, dry day and the traffic is fairly light. The speed limit of the road is 70mph.

**Speeding on a residential road:** Imagine you are driving along a residential road with cars parked either side or connecting side roads at various points. Pedestrians are also visible. The speed limit of the road is 30 mph.

**Speeding on an urban road:** Imagine you are driving along an urban road. The traffic is fairly light. Although there are houses either side of the road there does not appear to be many pedestrians. The speed limit of the road is 40 mph.

**Disengaging an ISA system:** Imagine you are driving a car that is fitted with Intelligent Speed Adaptation. When you start up the car you are automatically speed limited. You cannot drive above the posted speed limit unless you decide to press one of the override buttons and disengage the system. If you disengage the system you are free to travel at your desired speed.

**Individual TPB measures**

The questionnaires included direct and indirect measures of the TPB constructs.

*Intention* was assessed using three items. Items sought to measure *intentions* (one item; 'I would intend to exceed the 70mph speed limit on a motorway', strongly disagree-strongly agree, scored −3 to +3), *desire* (one item; 'I would want to exceed the 30mph speed limit on a residential road', strongly disagree-strongly agree, scored −3 to +3) and *planning* (one item; 'I would plan to exceed the 40mph speed limit on an urban road', strongly disagree-strongly agree, scored −3 to +3). Distinctions here were based on Conner and Sparks (1996) recommendations and higher scores reflect stronger intentions to perform the behaviour. Factor analysis confirmed that the three items loaded onto one dimension for each behaviour. The mean of these three items produced a composite scale for each of the four questionnaires.

**Table 4: Reliability scores of intention measures**

| Scenario | Pre ISA | During ISA | Post ISA |
|---|---|---|---|
| Motorway 70 mph | 0.9574 | 0.9574 | 0.9636 |
| Residential 30 mph | 0.7941 | 0.8021 | 0.8280 |
| Urban 40 mph | 0.8837 | 0.7397 | 0.8333 |
| Disengage ISA | 0.5629 | 0.6750 | 0.8684 |

*Perceived behavioural control* (PBC) was assessed using six items. These items were differentiated in terms of *perceived difficulty* (two items; e.g., 'For me to disengage the ISA system would be…', difficult-easy, scored +1 to +7), *perceived control* (three items; e.g., 'How much control would you have over exceeding the speed limit on a motorway?', no control-complete control, scored +1 to +7) and *self efficacy* (one item; 'How confident are you that you will be to exceed the 30mph speed limit on a residential road?', not very confident-very confident, scored +1 to +7), as proposed by Conner and Sparks (1996) and Trafimow, Sheeran, Conner and Finlay (2002). Factor analysis with varimax rotation revealed inconsistent loading onto the three factors (perceived difficulty, perceived control and self efficacy) across the four questionnaires. Therefore the three indexes for perceived behavioural were collapsed to form one scale. The mean of these six items produced a composite scale for each of the behaviours. Higher scores reflected greater perceptions of control in the commission of the behaviour.

**Table 5: Reliability score for PBC measures**

| Scenario | Pre ISA | During ISA | Post ISA |
|---|---|---|---|
| Motorway 70 mph | 0.6603 | 0.9062 | 0.7256 |
| Residential 30 mph | 0.8287 | 0.8152 | 0.8130 |
| Urban 40 mph | 0.7747 | 0.9259 | 0.8817 |
| Disengage ISA | 0.8279 | 0.8276 | 0.9210 |

*Attitude* was assessed by eight semantic differential scales following the statement 'Exceeding the 40mph speed limit on an urban road would be…' Following Lawton, Parker, Manstead and Stradling's (1997) distinction, the seven point scales measured both instrumental (useless-useful, harmful-beneficial, negative-positive, bad-good) and affective attitudes (unsafe-safe, unsatisfying-satisfying, not enjoyable-enjoyable, reckless-cautious). Factor analysis with varimax rotation revealed inconsistent loading onto two factors across the four questionnaires. The two separate indexes for instrumental and affective attitudes were collapsed to form one attitude scale for each behaviour. The mean of the eight items (all scored −3 to +3) produced a composite scale for each of the behaviours such that higher scores indicate attitudes that were in favour of the commission of the behaviour.

**Table 6: Reliability scores for attitude measures**

| Scenario | Pre ISA | During ISA | Post ISA |
|---|---|---|---|
| Motorway 70 mph | 0.9296 | 0.9038 | 0.9392 |
| Residential 30 mph | 0.8311 | 0.8955 | 0.9467 |
| Urban 40 mph | 0.9347 | 0.9449 | 0.9502 |
| Disengage ISA | 0.7261 | 0.8699 | 0.9002 |

*Normative beliefs* Four salient referents were identified; the police, family, other road users and other spouse/partner. Four items measured normative beliefs (e.g., 'The police would disapprove of me disengaging the ISA system', strongly disagree-strongly agree, scored −3 to +3). Higher scores reflected normative beliefs that supported or opposed the behaviour (see findings).

*Motivations to comply* were assessed using four items (e.g., 'Generally speaking how much do you want to do what your family think you should do?', not at all-very much, scored +1 to +7). Higher scores reflected a stronger motivation to comply with the referents.

*Behavioural beliefs* were measured using six items (e.g., 'Exceeding the 70mph speed limit on a motorway would risk causing an accident', unlikely-likely, scored −3 to +3). Higher scores reflected beliefs that the outcome was likely.

*Outcome evaluations* were assessed using six items (e.g., 'Making rapid progress would be…, bad to good, scored −3 to +3). Higher scores reflected outcome evaluations that were positive.

*Control Beliefs* were measured using seven items ('driving at nighttimes makes my exceeding the 40mph speed limit', unlikely-likely, scored −3 to +3). Higher scores reflected beliefs that the outcome was likely. Three additional items were included for disengage scenario.

*Frequency* of beliefs was measured using seven items ('I drive on urban roads at night time', never-frequently, scored +1 to +7). Higher scores reflected behaviours that were more frequent. Three additional items were included for disengage scenario.

*Moral norm* was assessed using a single seven-point item ('it would be quite wrong for me to exceed the 30mph on a residential road, strongly disagree-strongly agree, scored +1 to +7). Higher scores reflected stronger moral norms.

*Anticipated regret* was measured as the mean of two seven-point items (e.g., 'I would regret exceeding the 40mph speed limit on an urban road', unlikely-likely, scored −3 to +3). Higher scores reflected stronger feelings of anticipated regret.

**Table 7: Reliability scores for anticipated regret measures**

| Scenario | Pre ISA | During ISA | Post ISA |
|---|---|---|---|
| Motorway 70 mph | 0.7156 | 0.8868 | 0.9688 |
| Residential 30 mph | 0.8354 | 0.8795 | 0.8848 |
| Urban 40 mph | 0.8700 | 0.9468 | 0.8852 |
| Disengage ISA | 0.8793 | 0.9415 | 0.9650 |

*Past behaviour* was tapped by two seven point items (e.g., 'In the past I have frequently disengaged the ISA system', strongly disagree-strongly agree, and scored 1 to 7). Higher scores reflected more frequent commission of the behaviour in the past.

**Table 8: Reliability scores for past behaviour measures**

| Scenario | Pre ISA | During ISA | Post ISA |
|---|---|---|---|
| Motorway 70 mph | 0.9552 | 0.9413 | 0.8880 |
| Residential 30 mph | 0.9531 | 0.8762 | 0.8839 |
| Urban 40 mph | 0.9204 | 0.7484 | 0.9599 |
| Disengage ISA | – | 0.8822 | – |

*Self-identity* was measured using one single item (e.g., 'I see myself as a safe driver', strongly disagree-strongly agree, scored +1 to +7). Higher scores reflected a stronger sense of self-identity.

*Risk perception* was assessed using one item (e.g., What is the risk of being involved in a accident if you exceed the 70mph speed limit on a motorway', very low risk-very high risk, scored +1 to +7). Higher scores reflected higher perceptions of risk.

#### 2.5.2.3 Acceptability

Driver acceptance of the ISA system under different penetration levels was measured using an acceptability scale of advanced transport telematics developed by Van de Laan, Heino and De Waard (1997). The simple scale provided a direct measure of attitudes towards systems. Nine items measured participant's views of ISA allowing system evaluation across the dimensions of usefulness and satisfaction. Administration of the questionnaire at four time points allowed the calculation of an end score for each participant on the two dimensions of "usefulness" (e.g., useful-useless, scored +2 to –2) and "satisfaction" (e.g., pleasant-unpleasant, scored +2 to –2). A practical system evaluation was gauged by the usefulness score, whilst satisfaction scores reflected the systems pleasantness. High scores reflected positive appraisals of the systems usefulness and high satisfaction with the system. In a comparison of six studies high scale reliability was found (Van de Laan, Heino and De Waard, 1997). De Waard, Van der Hurst and Brookhuis (1999) have since utilized the scale. Comte's (2000) inclusion of the acceptability scale in her investigation into the impact of Intelligent Speed Adaptation on driver behaviour alludes to its merit in the present study.

**Table 9: Reliability scores for acceptability measures**

| Measure | Time 1 | Time 2 | Time 3 | Time 4 |
|---|---|---|---|---|
| Usefulness | 0.5146 | 0.7408 | 0.8197 | 0.8504 |
| Satisfaction | 0.6380 | 0.9046 | 0.8781 | 0.9035 |

#### 2.5.2.4 Driver Behaviour Questionnaire

Self reported driving violations and errors were assessed using the shortened 24-item version of the Driver Behaviour Questionnaire (Parker, Reason, Manstead and Stradling, 1995). This instrument measured the frequency with which individuals commit various types of errors and violations when driving, identifying three distinct types of aberrant driving behaviours; errors, lapses and violations. Participants were presented with 24 aberrant driving behaviours and asked to rate how often they have committed these (0 = never, 1 = hardly ever, 2 = occasionally, 3 = quite often, 4 = frequently, 5 = nearly all the time). In a comparison between the 50-item and 24-item scale good internal consistency has been found for each of the three subscales (Cronbach's $\alpha$ coefficients 0.84 for the errors, 0.8 for the violations, and 0.72 for lapses). The three factors first identified in Reason, Manstead, Stradling, Baxter and Campbell (1990) was confirmed. Test-retest correlation's also demonstrated reliability over time (time1 and time 2 correlations were 0.69 for error scale, 0.81 for the violation scale and 0.75 for the lapse scale).

Eight items measured *errors* (e.g., 'Attempt to overtake someone that you hadn't noticed to be taking a right turn', never-nearly all the time; scored 0 to +5). High scores reflected a greater propensity to perform the behaviour.

Eight items measured *lapses* (e.g., 'Attempt to drive away from traffic lights in third gear', never-nearly all the time; scored 0 to +5). High scores reflected a greater propensity to perform the behaviour.

Eight items measured *violations* (e.g., 'Disregard the speed limits late at night or early in the morning', never-nearly all the time; scored 0 to +5). High scores reflected a greater propensity to perform the behaviour.

**Table 10: Reliability scores for DBQ measures**

| Measure | Time 1 | Time 2 | Time 3 | Time 4 |
|---|---|---|---|---|
| Lapse | 0.7006 | 0.6919 | 0.6970 | 0.5492 |
| Error | 0.6001 | 0.7250 | 0.6568 | 0.6877 |
| Violation | 0.3107 | 0.7229 | 0.6300 | 0.6494 |

#### 2.5.2.5 Sensation seeking

The Arnett (1994) Sensation Seeking Scale was used. Although the Sensation Seeking Scale Form V (Zuckerman, 1994) is one of the most popular and widely used sensation seeking scales (especially in driver behaviour research, see Jonah, 1997) it was felt that the 40 forced choice items would overload the respondents given the lengthy nature of the TPB questionnaires. As Arnett points out, it is often hard for individuals to chose between these items when both or neither applies. Secondly, since many of the items relate to physical activity, it may be that any age differences in responses would indicate differences in physical strength and not sensation seeking. The Arnett sensation seeking scale provided a short 20 item questionnaire which asked respondents to rate how likely each described them. The scale is composed of two dimensions; novelty and intensity. The internal reliability of each was tested.

*Novelty subscale* 10 items measured novelty (e.g., 'I think it fun and exciting to perform or speak in front of a group', does not describe me at all-describes me very well, scored +1 to +4; Cronbach's $\alpha = 0.09$).

*Intensity subscale* 10 items assessed intensity (e.g., 'When I listen to music I like it to be loud', does not describe me at all-describes me very well scored +1 to +4; Cronbach's $\alpha = 0.60$)

Higher scores reflected a higher level of sensation seeking.

This questionnaire will be included within the analysis of the four trials.

#### 2.5.2.6 Driving Style Questionnaire

The DSQ (West, Elander and French, 1992) contains 15 items based on behaviours that are associated with risky driving behaviour. Participants were asked on what basis they engaged in these behaviours (never or very infrequently-very frequently or always; scored +1 to +5).

This questionnaire will be included within the analysis of the four trials.

#### 2.5.2.7 Conscientiousness

The facets of conscientiousness were measured using a questionnaires developed as part of the International Personality Item Pool. Five facets were taken to represent those in the NEO-PI-R (http://ipip.ori.org/newNEOKey.htm)

*Self efficacy* 10 items measured self efficacy (e.g., 'complete task successfully', very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.81).

*Orderliness* 10 items measured orderliness (e.g., 'like order', very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.82).

*Dutifulness* 10 items measured dutifulness (e.g., 'try to follow the rules, very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.52).

*Achievement Striving* 10 items measured achievement striving (e.g., 'demand quality' very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.83).

*Self Discipline* 10 items measured self discipline (e.g., 'get chores done right away', very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.84).

*Cautiousness* 10 items measured cautiousness (e.g., 'Avoid mistakes' very inaccurate-very accurate scored +1 to +5; Cronbach's α = 0.89).

Higher scores reflected a higher level of conscientiousness.

This questionnaire will be included within the analysis of the four trials.

#### 2.5.2.8 Questionnaire administration

Questionnaires were generally administered at four time points;

Time 1: one month prior to ISA control,
Time 2: following one month ISA control,
Time 3: following four months ISA control and
Time 4: following a one month return to non-ISA-controlled driving.

The majority of questionnaires were administered according to this timetable so that behavioural changes to ISA could be monitored. However as can be seen in Table 11 certain questionnaires were administered at a differing schedule. Personality measures such as the sensation seeking, conscientiousness and the driving style questionnaire were administered at Time 1 only since personality traits are assumed to remain constant over time. It was also felt too difficult to expect participants to make certain judgments regarding system safety and design without any experience of the system. At Time 4 questionnaires relating to ISA usage became irrelevant. The TPB was administered at 3 time points only.

**Table 11: Administration schedule for questionnaires**

| Questionnaire | Phase 1 | Phase 2 | | Phase 3 |
|---|---|---|---|---|
| | Time 1 | Time 2 | Time 3 | Time 4 |
| Demographic/general driving | ✓ | | | |
| TPB | ✓ | | ✓ | ✓ |
| NASA RTLX | ✓ | ✓ | ✓ | ✓ |
| Acceptability | ✓ | ✓ | ✓ | ✓ |
| DBQ | ✓ | ✓ | ✓ | ✓ |
| Sensation Seeking | ✓ | | | |
| Conscientiousness | ✓ | | | |
| General speeding | ✓ | ✓ | ✓ | ✓ |
| Concentration | ✓ | ✓ | ✓ | |
| Experience of system | ✓ | ✓ | ✓ | |
| System design and safety | | ✓ | ✓ | |
| System trust | | ✓ | ✓ | |
| Stakeholder | ✓ | | ✓ | |

# 3. ANALYSIS OF VEHICLE DATA

## 3.1 Introduction

This chapter presents analysis of vehicle data. Data completeness is reviewed in the next section, followed by analysis of trip based data, and analysis of vehicle speed. In addition to analysing speed distributions in individual speed zones, the effect of ISA intervention was also examined by demographic factors in terms of gender, age, and intention to speed.

## 3.2 Data completeness

Each participant was expected to generate 168 days of travelling data. Interruption to data collection was attributable to various ISA system failures. The overall completion rate was 91%. Table 12 presents the completion rate achieved by individual participants, while Figure 4 illustrates a breakdown of data completeness per participant across trial phases.

**Table 12: Data completeness in Field Trial 2**

| Participant ID | Completed days | Completion rate (%) |
|---|---|---|
| 30 | 160 | 95.2 |
| 31 | 157 | 93.5 |
| 32 | 161 | 95.8 |
| 33 | 155 | 92.3 |
| 34 | 147 | 87.5 |
| 35 | 156 | 92.9 |
| 36 | 158 | 94.0 |
| 37 | 157 | 93.5 |
| 38 | 155 | 92.3 |
| 39 | 163 | 97.0 |
| 40 | 165 | 98.2 |
| 41 | 147 | 87.5 |
| 42 | 131 | 78.0 |
| 43 | 163 | 97.0 |
| 44 | 116 | 69.0 |
| 45 | 164 | 97.6 |
| 46 | 143 | 85.1 |
| 47 | 154 | 91.7 |
| 48 | 141 | 83.9 |
| 49 | 164 | 97.6 |
| **Overall completion rate** | | **91.0** |

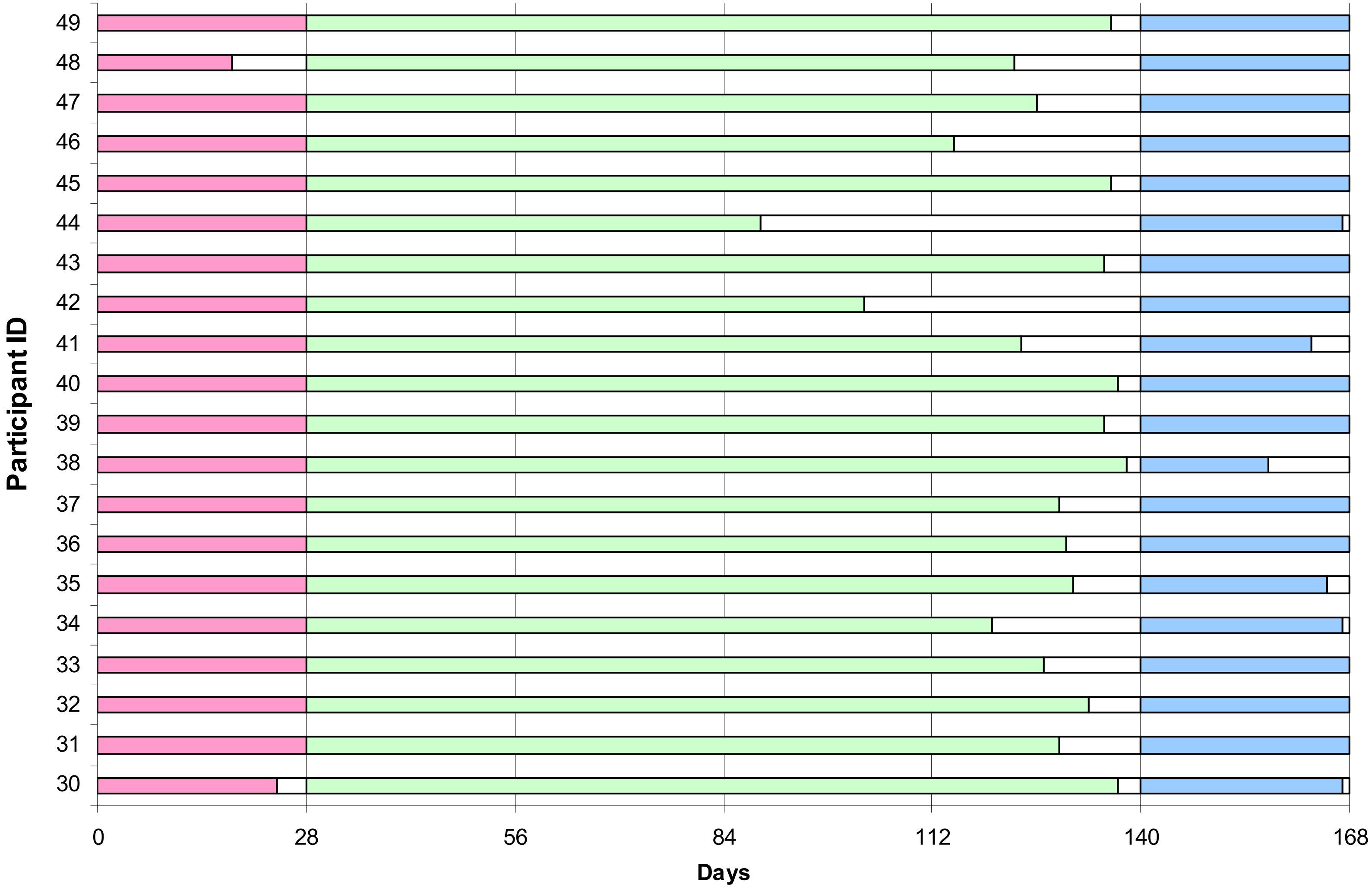



**Figure 4: Completion rate in Field Trial 2**

## 3.3 Analysis of trip-based measures

Table 13 depicts the means and ANOVA test results of trip-based measures. Trip duration, trip length, and fuel consumption appeared to decrease along the progress of the trial. There was however no statistical difference across trial phases with respect to trip length and fuel consumption. With respect to trip duration, Phase 1 and Phase 3 were different from each other ($p$ = 0.017); there were however no statistical difference between Phase 1 and Phase 2, as well as between Phase 2 and Phase 3.

**Table 13: Statistical test results of trip-based measures**

| Measure | Mean | | | ANOVA test results | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | F statistic | significance | Effect size |
| Trip Duration (minutes) | 18.09 (4.91) | 16.87 (4.81) | 16.14 (4.72) | $F(2,38) = 5.505$ | $0.008^{**}$ | 0.225 |
| Trip length (miles) | 8.19 (2.51) | 7.39 (2.68) | 7.38 (3.09) | $F(2,38) = 2.004$ | 0.149 | 0.095 |
| Fuel consumption (MPG) | 38.26 (2.73) | 37.48 (3.38) | 37.41 (3.86) | $F(2,38) = 2.155$ | 0.130 | 0.102 |

Note: 1. Figures in brackets underneath the mean values are standard deviation.
2. ** denotes the difference is significant at the 0.01 level

While there is no definite evidence for explaining the reasons behind the trend that these three measures decreased in line with trial progress, travel patterns as a result of seasonal differences might have contributed to such an interesting phenomenon. Most of the participants started their Phase 1 around late autumn and all participants finished their Phase 3 during early spring. The wintry condition may cause worse fuel economy as well as alter route choices. Based on the data obtained from this trial, no distinctive effect of ISA on trip duration, trip length, or fuel consumption was identified. However, further evidence may be revealed from the remaining field trials.

## 3.4 Analysis of vehicle speed

### *3.4.1 Data processing*

Although the data logging system in the vehicle generates data at 10Hz (i.e. 10 records per second), data used for analysis was distance based rather than time based. While time based data is intuitively valid, it introduces undue weight to the data stream when vehicle speed is zero (e.g. the vehicle stops at junctions) or very low (e.g. the vehicle moves slowly on a congested road). Conversion algorithms were developed for extracting a record per 5 metres of travelling distance from the data stream. This data processing also filtered out records without a valid speed limit attached to them, attributable to the vehicle being driven on roads which were not given speed limits by Navteq, such as private roads (e.g. supermarket car parks) or non-trunk roads outside the Leeds area. The above process led to a data file containing 23,187,300 valid records, across all participants and trial phases, ready for analysis.

Weighting across participants to equalise individuals' contribution of travel distance during the trial to the data was considered in order to prevent the data from being possibly distorted by participants with high annual mileage. However, it was eventually decided not to apply weights to retain a valid representation of the sample against the whole driving population, as annual mileage inherently differs from one driver to another.

### 3.4.2 Vehicle kilometres

Following data processing and reduction, the final data file ready for analysis represents a total travel distance of 115,937 kilometres. A breakdown of vehicle kilometres with respect to speed zones is illustrated in Figure 5. The largest portion of vehicle kilometres was attributable to 30 mph zones, followed by 70 mph zones. The distribution of vehicle kilometres spread rather equally between urban and rural areas. The vehicle kilometres recorded in the 20, 30, and 40 mph zones accounted for 52% of the total vehicle kilometres, against a sum of 48% contributed by the 50, 60, and 70 mph zones.

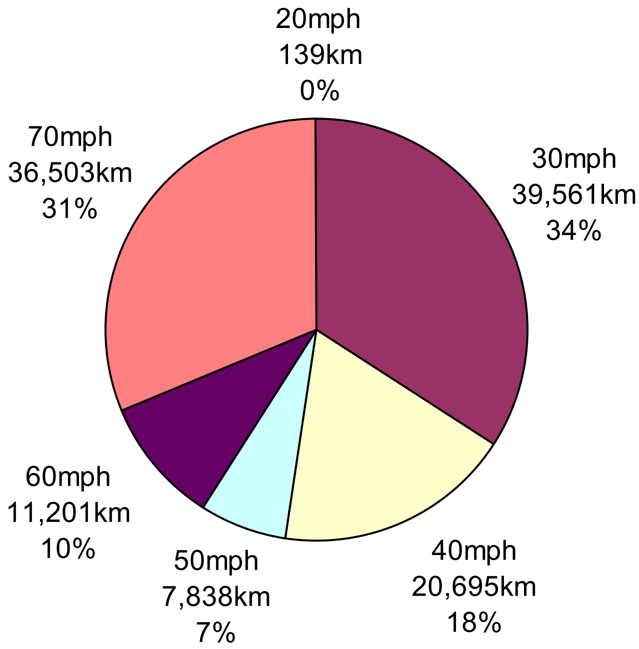



**Figure 5: Distribution of total vehicle kilometres with respect to speed zones**

Table 14 provides a further breakdown of the proportion of vehicle kilometres within individual trial phases, which suggests that the contribution of each speed zones to the total vehicle kilometres remains a very similar pattern across trial phases.

**Table 14: Vehicle kilometres across trial phases**

| Speed zone | Vehicle Kilometres | | | Distribution based on trial phase (%) | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 1 | Phase 2 | Phase 3 |
| 20 mph | 30 | 81 | 28 | 0.1 | 0.1 | 0.1 |
| 30 mph | 8,255 | 23,728 | 7,578 | 32.7 | 34.7 | 34.1 |
| 40 mph | 4,364 | 12,429 | 3,903 | 17.3 | 18.2 | 17.6 |
| 50 mph | 1,607 | 4,681 | 1,550 | 6.4 | 6.8 | 7.0 |
| 60 mph | 2,269 | 6,897 | 2,035 | 9.0 | 10.1 | 9.2 |
| 70 mph | 8,723 | 20,651 | 7,128 | 34.6 | 30.2 | 32.1 |
| Sum | 25,248 | 68,467 | 22,221 | 100 | 100 | 100 |

### 3.4.3 Speed distribution

The logged vehicle data provides a comprehensive database of the speed distribution. Figure 6 through Figure 11 illustrate speed distribution across speed zones from 20 mph to 70 mph respectively. Each figure consists of two graphs; the top graph shows speed distribution across trial phases, and the bottom graph shows speed distribution in Phase 2 only (i.e. when ISA was switched on), with a breakdown of system engaged (Opt-In) and system overridden (Opt-Out).

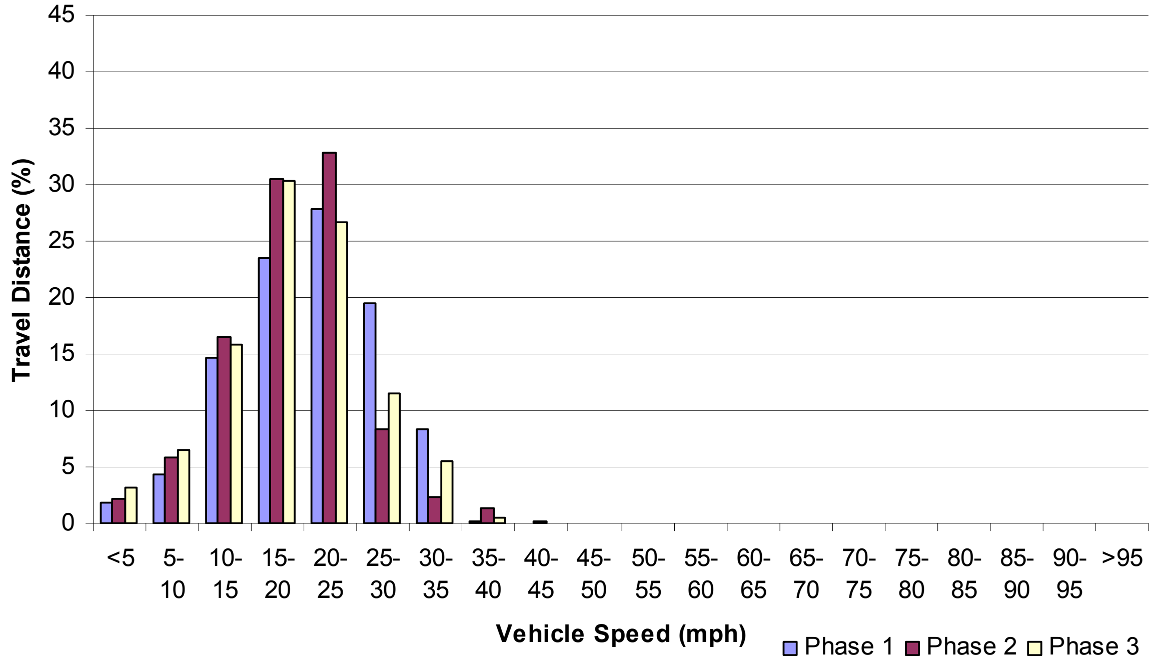
It is worth noting that participants seemed to have adapted their reference for their chosen speed between trial phases. During Phase 1 and 3 when the ISA system was turned off, many participants were observed to obey the speed limits with reference to the speedometer reading. During Phase 2, most participants were observed to rely on the ISA system (i.e. throttle feedback) instead of the speedometer reading.

The current design of the ISA system does not precisely restrict vehicle speed to posted speed limits (i.e. the speed limits provided by the digital speed limit map stored in the vehicle) all the time. Considering that trial participants may encounter a wide variety of road gradients, tolerance has been given to the throttle cut-off thresholds allowing the vehicle to be able to reach the speed limits on uphill roads. This design however leads to the vehicle being able to cross the speed limits on flat or downhill roads.

Since the participants used the ISA system to provide feedback on the limit and went for the maximum throttle allowance, a slight distortion to the speed distribution when ISA was turned on was observed. This led to a slight drift of the speed distribution in Phase 2 around the legal speed limits, especially in lower speed zones. For example, in 20 mph zones (e.g. Figure 6), the peak of the speed distribution derived from Phase 2 was in the band of 20-25 mph rather than 15-20 mph. Nevertheless, the trial results undoubtedly demonstrate the effectiveness of the ISA system on reshaping speed distribution.

The effect of ISA intervention on the shape of the speed distribution is prominent across speed zones, except for the 60 mph zones, in which speeding behaviour had already rarely been recorded when ISA was not available. This is considered to be primarily due to the constrains on driving speed imposed by road geometry, as the 60 mph speed limit is applicable to most rural roads where the layout is usually single carriageway. It is worth noting that ISA led to considerably higher percentage of travel distance in the 55-60 mph band in Figure 10, which is considered to be attributable to the differences in participants' reference for their chosen speed across trial phases. As explained earlier in this section, most participants were observed to rely on throttle feedback instead of the speedometer reading for their chosen speed when ISA was switched on. Therefore they might have unintentionally pushed the accelerator further down than they normally would (i.e. when ISA was off), because ISA control still allowed them to do so before reaching the speed limit.

Analysis of the above speed distribution figures also reveals that the shapes of the speed distribution from Phase 1 and Phase 3 were generally very similar, apart from 20 mph zones. This suggests that, although ISA effectively changed the speed distribution, the carry-over effect was minimal.



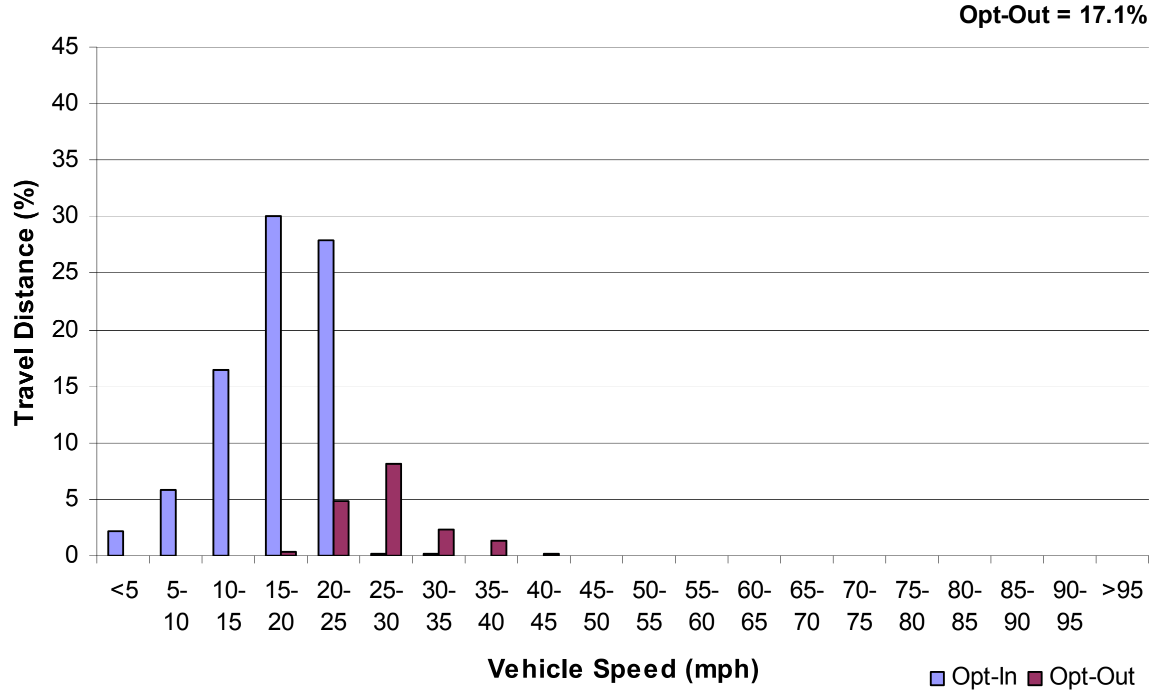
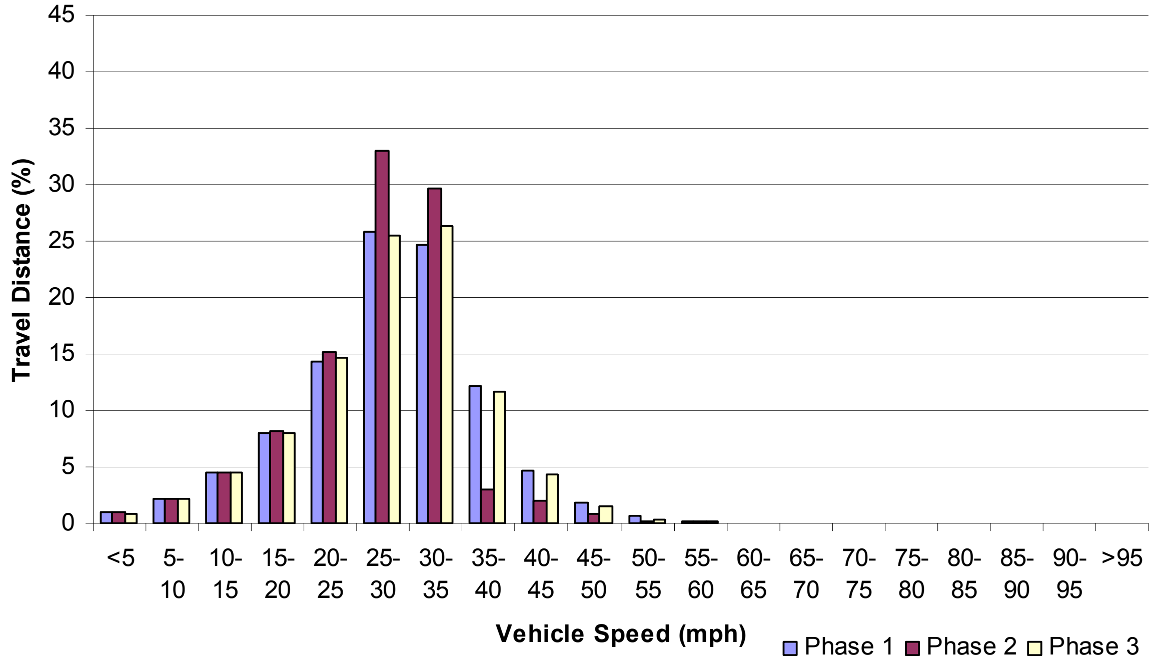




**Figure 6: Overall speed distribution in 20 mph zones**



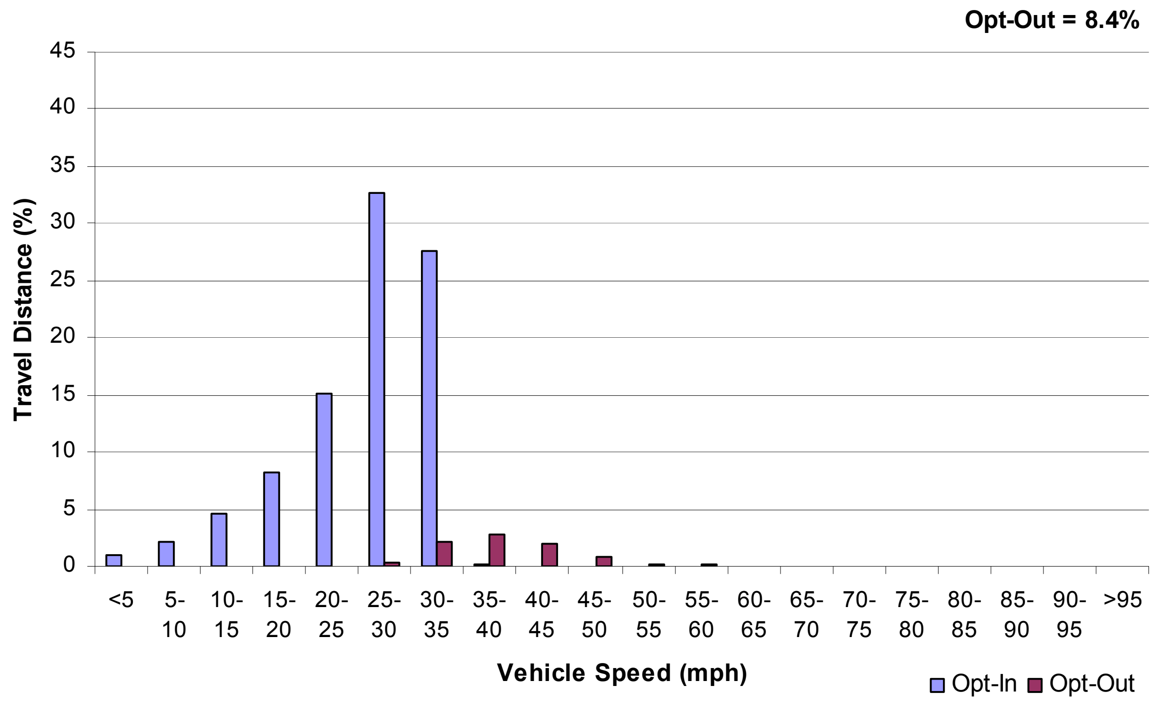
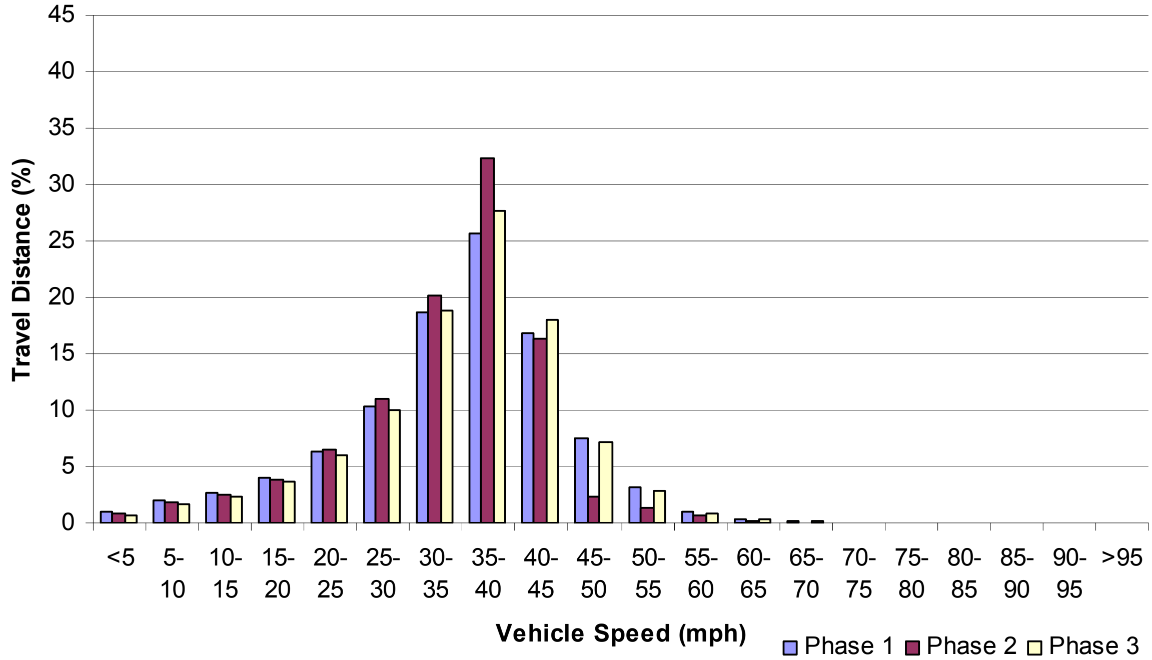




**Figure 7: Overall speed distribution in 30 mph zones**



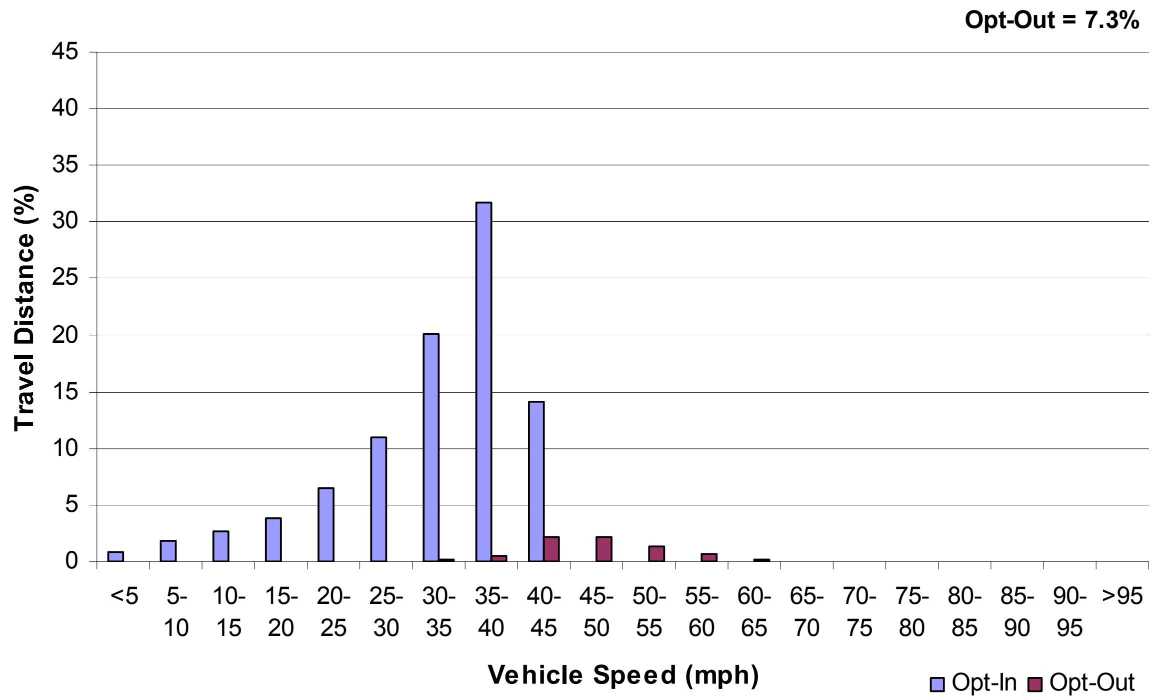




**Figure 8: Overall speed distribution in 40 mph zones**

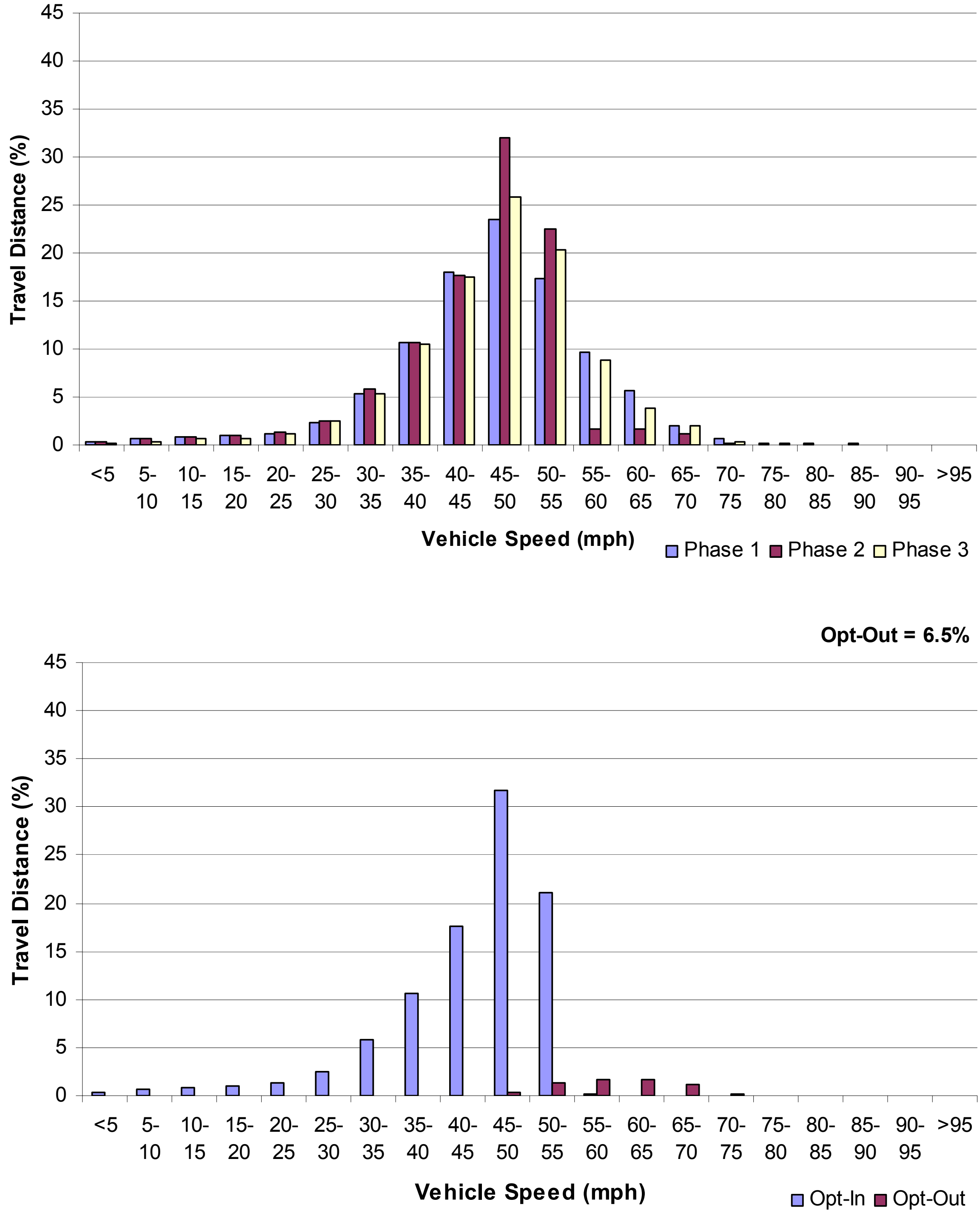



**Figure 9: Overall speed distribution in 50 mph zones**

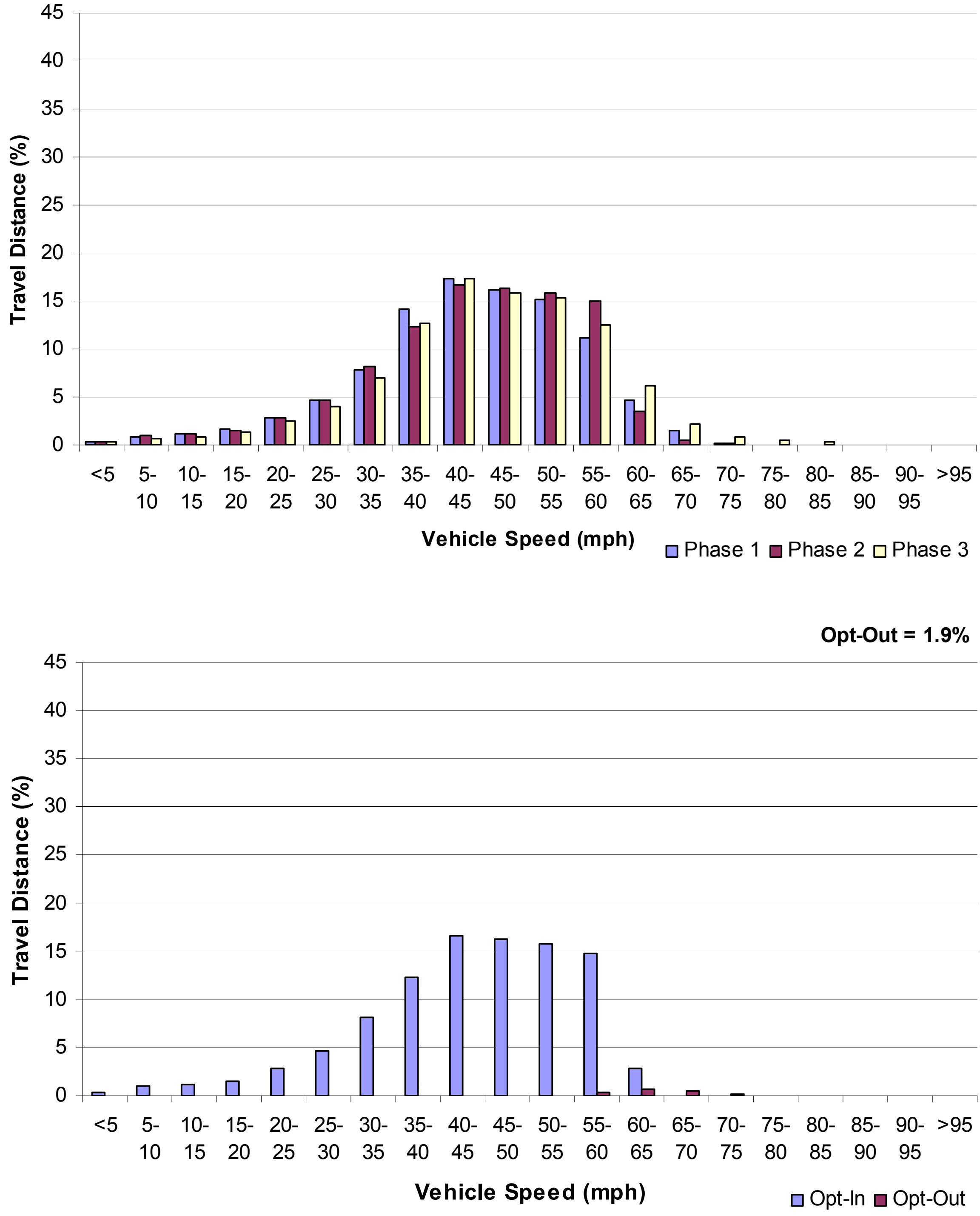



**Figure 10: Overall speed distribution in 60 mph zones**

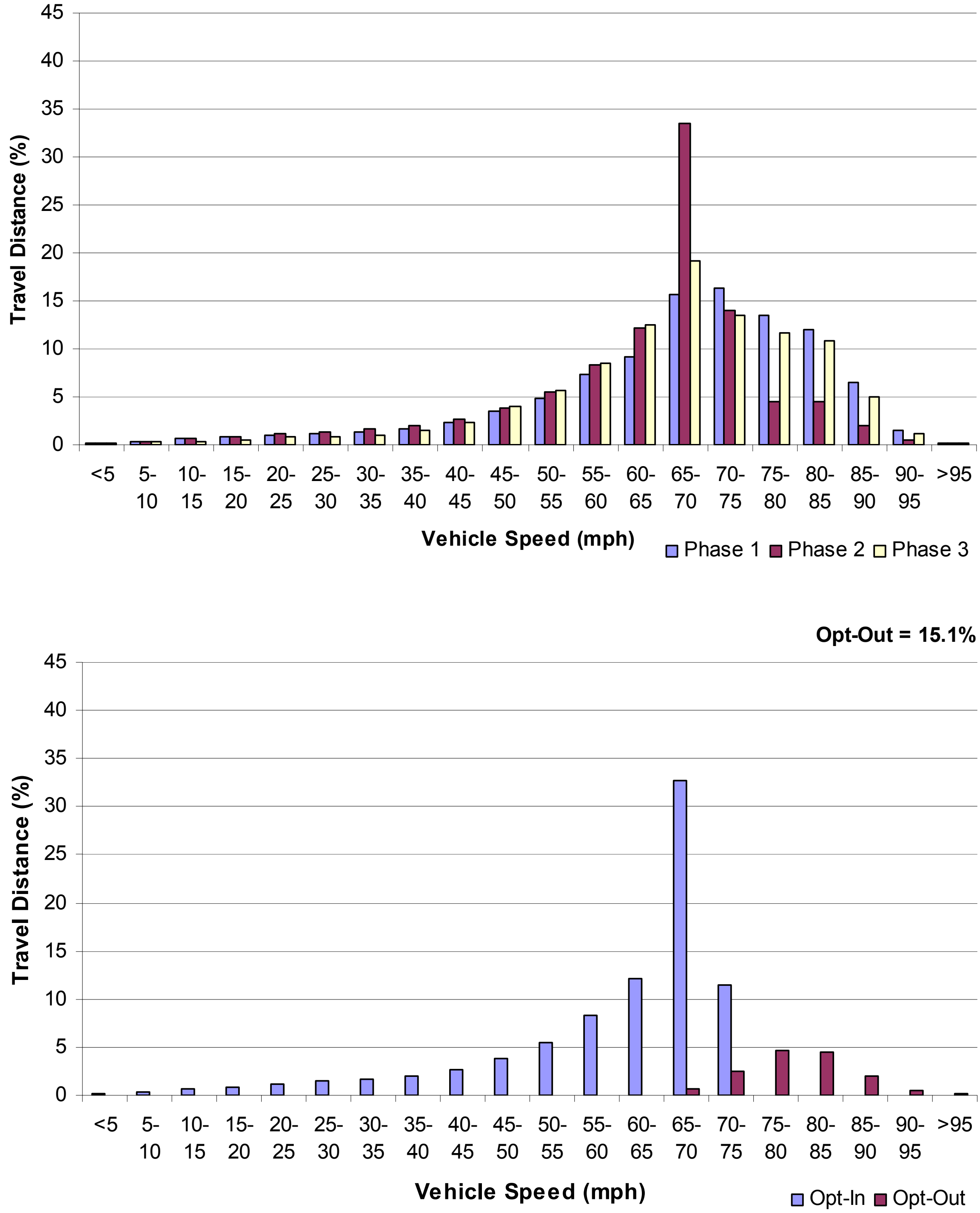



**Figure 11: Overall speed distribution in 70 mph zones**

### 3.4.4 Compliance with ISA intervention

As illustrated in Figure 6 through Figure 11, in speed zones where a substantial portion of the speed distribution was over the posted speed limits during Phase 1 and 3, considerable ISA overriding was also observed during Phase 2. This suggests that drivers who used to speed might find it difficult to refrain from speeding at the presence of an overridable ISA system. This phenomenon clearly highlights the value of introducing a mandatory ISA system over advisory ISA system in order to reinforce compliance with speed limits. Although an overridable ISA system may be considered to be useful under certain circumstances (e.g. overtaking a show moving lorry), its effect on transforming speed distribution and therefore enhancing road safety could be compromised by excessive overriding.

Figure 12 compares the observed overriding behaviour across speed zones, which highlights concerns over the influence of ISA intervention on diminishing speed behaviour due to the system being overridden, especially in lower speed zones where drivers are most likely to encounter vulnerable road users such as pedestrians and cyclists. It is notable that ISA was overridden for around 15% of travel distance on 70 mph roads. The proportion of overriding on the 20 mph roads was higher, but was for only a very small amount of total distance. The participants may have felt that speeding on 70 mph roads (mainly motorways) was acceptable whereas speeding on urban roads was not.

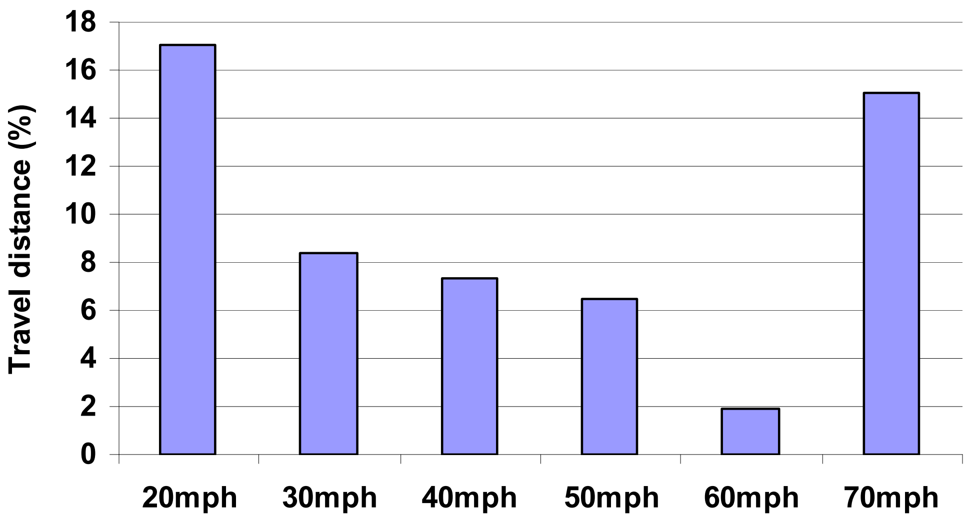



**Figure 12: Comparison of overriding behaviour across speed zones**

Figure 13 illustrates the distribution of overriding behaviour across speed zones based on the total travel distance when the ISA system was overridden, and demonstrates that a large proportion of overriding behaviour occurred in the urban environment (44%, contributed by 30 and 40 mph zones), where it could be argued that on safety grounds it was needed most. In addition, nearly half of the travel distance when ISA was overridden was recorded on 70 mph roads, which is due to the participants' overriding behaviour being magnified by travel distance achieved on high-speed roads.

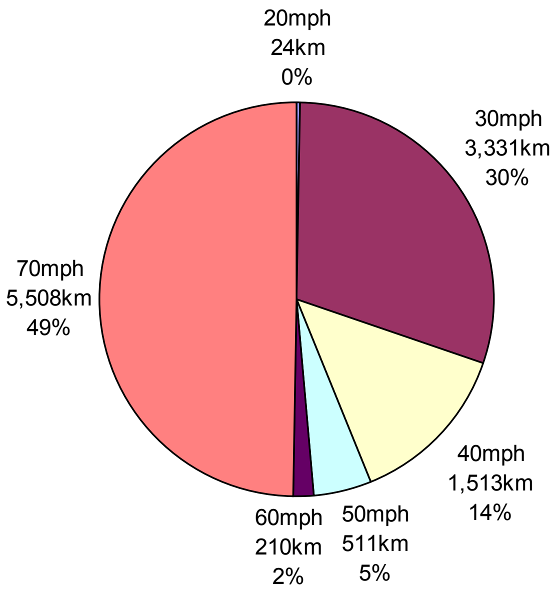



**Figure 13: Distribution of travel distance with ISA overridden**

### 3.4.5 Comparison of vehicle speed across trial phases

In addition to discussions of ISA changing the shape of speed distribution, the statistical differences among speed distributions was examined by central tendency (e.g. mean, median, and mode) as well as key percentiles towards the right end of the distribution (e.g. the 85th, 90th and 95th percentile). The high percentiles of the speed distribution offer very useful information for inspecting the presence of speed violation, especially the 85th percentile which closely corresponds to one standard deviation above the mean of a normal distribution. Moreover, traffic engineers have commonly used the 85th percentile of the speed of free flow traffic for determining speed limits. Therefore, a reduced value of the 85th (as well as the 90th and the 95th) percentile speed would be an indication of diminished speed violation.

The data were integrated on the basis of individual participants with respect to trial phases and speed zones allowing repeated measures ANOVAs to be carried out against key statistics of the speed distribution in each speed zone across trial phases. Statistics tests were carried out against central tendency of the distribution via the mean, the median, and the mode, and against the skewness of the distribution towards the right end via the 85th, the 90th, and the 95th percentile. Given that the ANOVA results and the trend of changes across trial phases were very similar for the three statistics indicating central tendency and across the three high percentiles, one measure was chosen to reflect each. Due to the importance of the mean and the 85th percentile of the speed distribution to research into subjective choice of speed, only these two statistics are presented and discussed as follows.

Figure 14 illustrates comparison of these two key statistics across trial phases in each speed zone, which suggests that ISA consistently reduced the mean and the 85th percentile of the speed distribution across speed zones, apart from the 60mph zones; i.e. a ‘V’ shape, the statistic in question goes down from Phase 1 to Phase 2, then rises again from Phase 2 to Phase3. The absence of the ‘V’ shape in the 60 mph zones is considered to be primarily attributable to the behavioural changes in participants’ reference for their chosen speed between trial phases, as discussed earlier in this section.

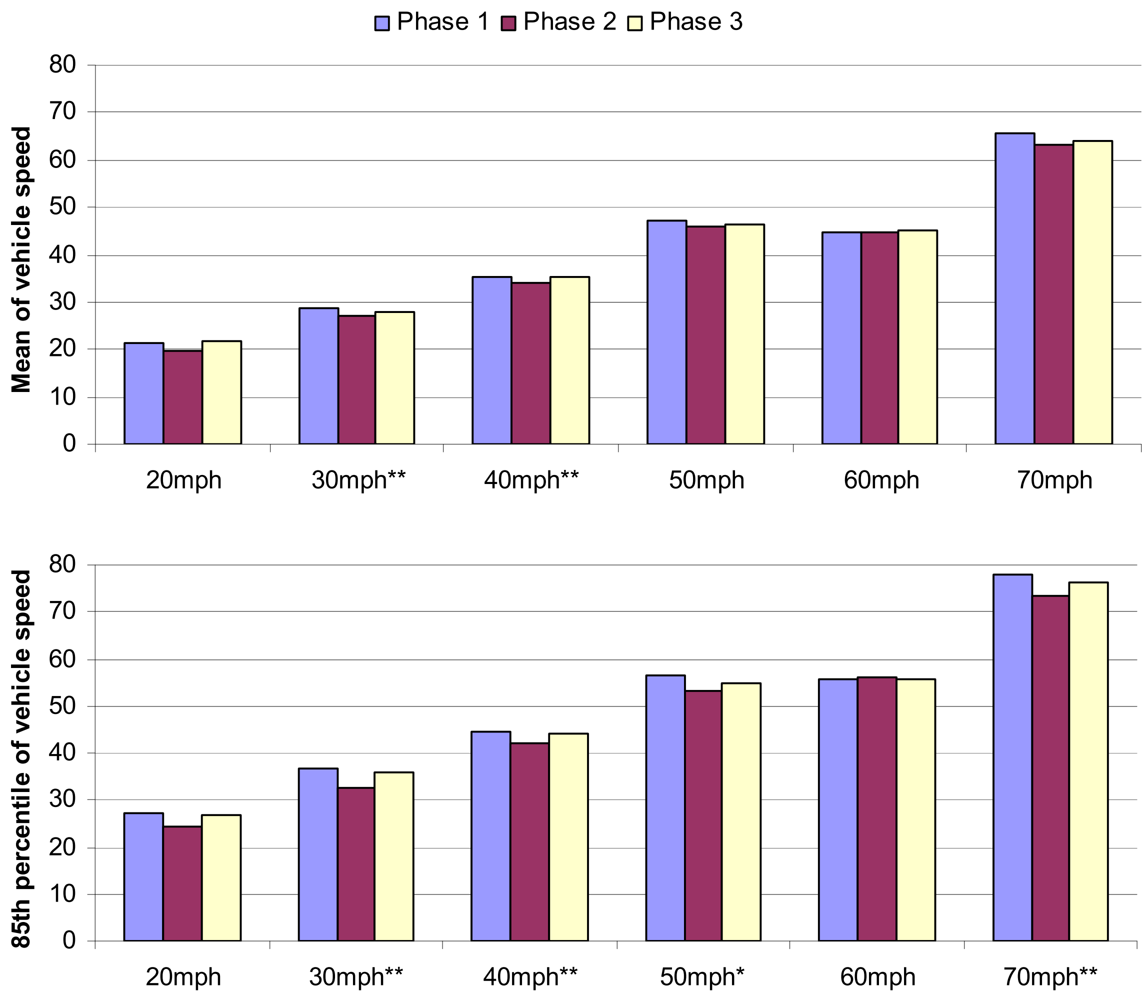



**Figure 14: Comparison of key statistics of the speed distribution across trial phases**

Table 15 presents the test results of a series of repeated measures ANOVAs, which confirm that ISA effectively changed the speed distribution, especially in urban areas where lower speed limits normally apply. It is worth noting that the significance of the ANOVA test results largely depends on sample size. For example, the difference in mean speed in the 50 and the 70 mph zones may become statistically significant when the sample size increases (i.e. more vehicles on the road are equipped with ISA).

The results of the ANOVA also indicate that ISA intervention was more effective in reducing excessive speed than mean speed. This is demonstrated by larger effect sizes derived from the $85^{th}$ percentiles than from the mean speeds across speed zones. Since injury severity is related to speed reduction (Nilsson, 1981), the cut-down of excessive speed delivers promising implications to road safety.

In addition, the data used for the ANOVA include the travel distance when ISA was overridden in Phase 2, which suggests that the effectiveness of ISA intervention in diminishing speeding behaviour has not been traded off by the system being overridable. This undoubtedly boosts the confidence in suggesting that a mandatory ISA system will further diminish speeding behaviour.

**Table 15: Results of ANOVA for key statistics of the speed distribution**

| Statistic | Speed zone | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA: *F* statistic | Repeated measures ANOVA: significance | Repeated measures ANOVA: Effect size | Post-hoc t-tests: PH1 vs PH2 | Post-hoc t-tests: PH1 vs PH3 | Post-hoc t-tests: PH2 vs PH3 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean speed | 20 | 21.51 | 19.60 | 21.66 | F(2,16) = 1.25 | 0.313 | 0.135 | ** | × | × |
| | 30 | 28.55 | 27.03 | 28.05 | F(2,38) = 14.96 | < 0.0005** | 0.440 | ** | × | ** |
| | 40 | 35.13 | 34.13 | 35.28 | F(2,38) = 5.51 | 0.008** | 0.225 | ** | × | ** |
| | 50 | 47.31 | 45.83 | 46.35 | F(2,38) = 2.29 | 0.115 | 0.108 | * | × | × |
| | 60 | 44.73 | 44.90 | 45.15 | F(2,38) = 0.20 | 0.822 | 0.010 | × | × | × |
| | 70 | 65.47 | 63.06 | 64.08 | F(2,38) = 1.82 | 0.176 | 0.087 | * | × | × |
| 85th percentile | 20 | 27.04 | 24.43 | 26.79 | F(2,16) = 1.48 | 0.258 | 0.156 | ** | × | × |
| | 30 | 36.60 | 32.46 | 35.84 | F(2,38) = 40.51 | < 0.0005** | 0.681 | ** | × | ** |
| | 40 | 44.56 | 41.86 | 44.11 | F(2,38) = 10.58 | < 0.0005** | 0.358 | ** | × | ** |
| | 50 | 56.64 | 53.30 | 55.03 | F(2,38) = 3.67 | 0.035* | 0.162 | * | × | * |
| | 60 | 55.76 | 56.10 | 55.51 | F(2,38) = 0.28 | 0.754 | 0.015 | × | × | × |
| | 70 | 78.09 | 73.30 | 76.20 | F(2,38) = 6.63 | 0.003** | 0.259 | ** | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

### *3.4.6 Speed variability*

Table 16 presents the coefficient of variation (CV) derived from individual trial phases as well as speed zones, which indicates the variability of vehicle speed. CV is a dimensionless measure that allows comparison of the variation of populations having considerably different mean values, which is of particular use for this analysis since the speed zones range from 20 mph to 70 mph. ISA led to a reduction in CV in most speed zones, as the CV derived from Phase 2 was generally smaller than that from Phase 1 or 3, apart from the difference between Phase 1 and 2 in the 20 mph zones and between Phase 2 and 3 in the 70 mph zones. At the overall level, ISA also led to a reduction in CV.

The effect of ISA intervention on reducing speed variability was most prominent in the 30 and 40 mph zones, i.e. the urban area. This delivers a promising implication of implementing ISA to accident reduction, as it has been suggested that the CV of speed is significantly correlated with accident occurrence in urban areas but the relationship is less prominent in rural areas (Taylor et al, 2000; Taylor et al, 2002).

**Table 16: Coefficient of variation of vehicle speed across trial phases**

| Speed zone | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|
| 20 mph | 0.328 | 0.332 | 0.360 |
| 30 mph | 0.307 | 0.275 | 0.300 |
| 40 mph | 0.302 | 0.275 | 0.282 |
| 50 mph | 0.240 | 0.210 | 0.212 |
| 60 mph | 0.271 | 0.267 | 0.268 |
| 70 mph | 0.240 | 0.228 | 0.222 |
| Overall | 0.457 | 0.442 | 0.445 |

### 3.4.7 Jerks

It has been widely argued that braking is the most common evasion manoeuvre in traffic conflicts, ranging from 63% to 98% of traffic conflicts (van der Horst, 1984; Hyden, 1987; Garder, 1990; Hantula, 1994). Jerks, the sudden onset of *severe* deceleration, would therefore provide a useful indication of the occurrence of potential traffic conflicts.

The number of jerks was identified from the data stream. There were 7 jerks when ISA was switched on across all participants, against 8 jerks when ISA was switched off. However, the difference was not statistically significant ($F(1,19) = 0.073$, $p = 0.789$), primarily due to excessively small sample size.

It is not surprising that the number of jerks identified from this trial was small. According to Nygård (1999), only 6 serious traffic conflicts occurred during a field trial involving 24,080 samples of junction negotiation (i.e. 0.02%). It is expected that the remaining trials will be able to provide more data enabling the effect of ISA intervention on the occurrence of jerks to be further examined.

## 3.5 Analysis of vehicle speed by demographic groups

This section presents analysis of the speed distribution in terms of participants' demographic characteristics: gender, age, and intention to speed. The number of participants in each demographic group used in the analysis presented in this section is specified in Table 17. It should be noted that the number of participants is not completely counterbalanced across the dichotomous groups as a result of difficulties encountered during participant recruitment.

**Table 17: Number of participants by demographic categories**

| | Male | | Female | | Total |
|---|---|---|---|---|---|
| | Intender | Non-Intender | Intender | Non-Intender | |
| Young | 4 | 3 | 1 | 1 | 9 |
| Old | 6 | 4 | 1 | 0 | 11 |
| Total | 10 | 7 | 2 | 1 | 20 |

### 3.5.1 Gender

Table 18 depicts a breakdown of vehicle kilometres across trial phases, speed zones and participants' gender groups, which shows that male participants contributed to a considerably larger amount of data than female participants; this however was expected due to the highly imbalanced number of participants across the gender groups. Figure 15 further compares the distribution of travel distance between the two gender groups. Although there is no distinct within-group difference across trial phases, it clearly reveals that female participants drove in urban environments relatively more often than male participants.

**Table 18: Vehicle kilometres across trial phases, speed zones and gender groups**

| Speed zone | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 1 | Phase 2 | Phase 3 |
| 20 mph | 16 | 58 | 20 | 15 | 23 | 8 |
| 30 mph | 6,984 | 20,495 | 6,506 | 1,271 | 3,233 | 1,072 |
| 40 mph | 3,774 | 10,529 | 3,339 | 590 | 1,900 | 564 |
| 50 mph | 1,551 | 4,472 | 1,447 | 55 | 209 | 103 |
| 60 mph | 2,002 | 6,080 | 1,723 | 267 | 817 | 312 |
| 70 mph | 8,270 | 19,221 | 6,509 | 453 | 1,431 | 620 |
| Sum | 102,994 | | | 12,943 | | |

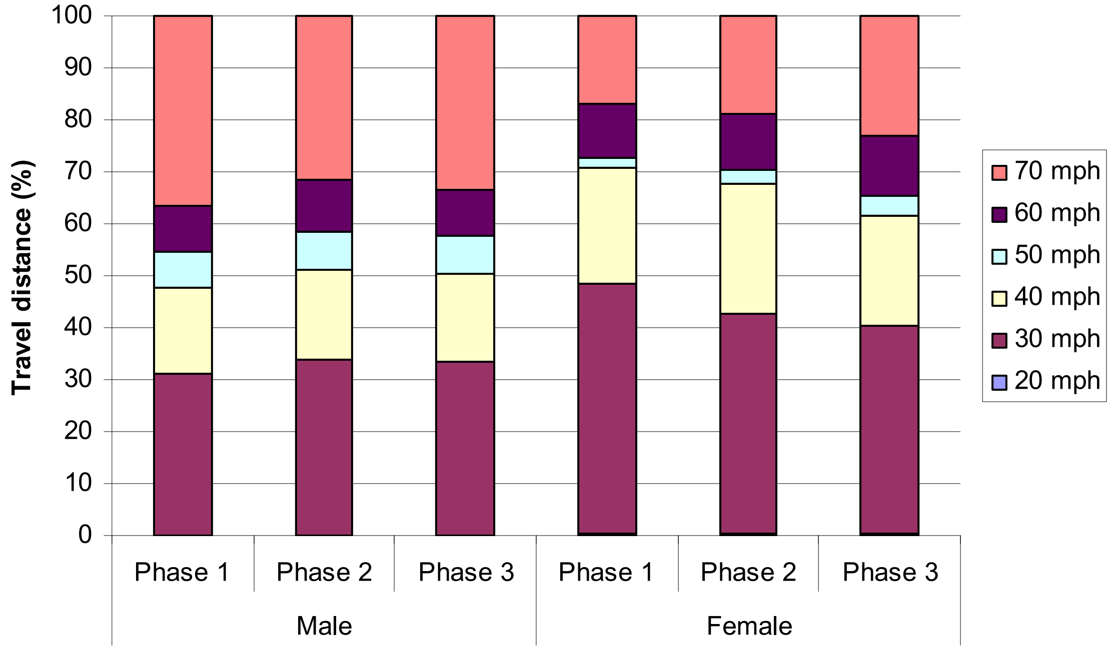



**Figure 15: Comparison of patterns of travel distance between gender groups**

Figure 16 through Figure 21 compare speed distribution across trial phases between the two gender groups. ISA effectively reshaped the speed distribution for both groups across speed zones, apart from female participants in the 20 mph zones. Female participants were also observed to have overridden the system more frequently than male participants across all of the speed zones.

Caution should be applied when interpreting the results of gender differences. As indicated in Table 17, there were only three female drivers participating in the trial and two out of the three were intenders (who with intention to break speed limits). Since the female samples were highly biased, the results of female speeding behaviour derived from this trial cannot be considered to be representative of all female drivers. Moreover, the excessive overriding rate of female participants recorded in the 20 mph zones was attributable to the fact that the only non-intender female participant did not drive in 20 mph zones at all during the trial; i.e. all data were collected from the two intender female participants.

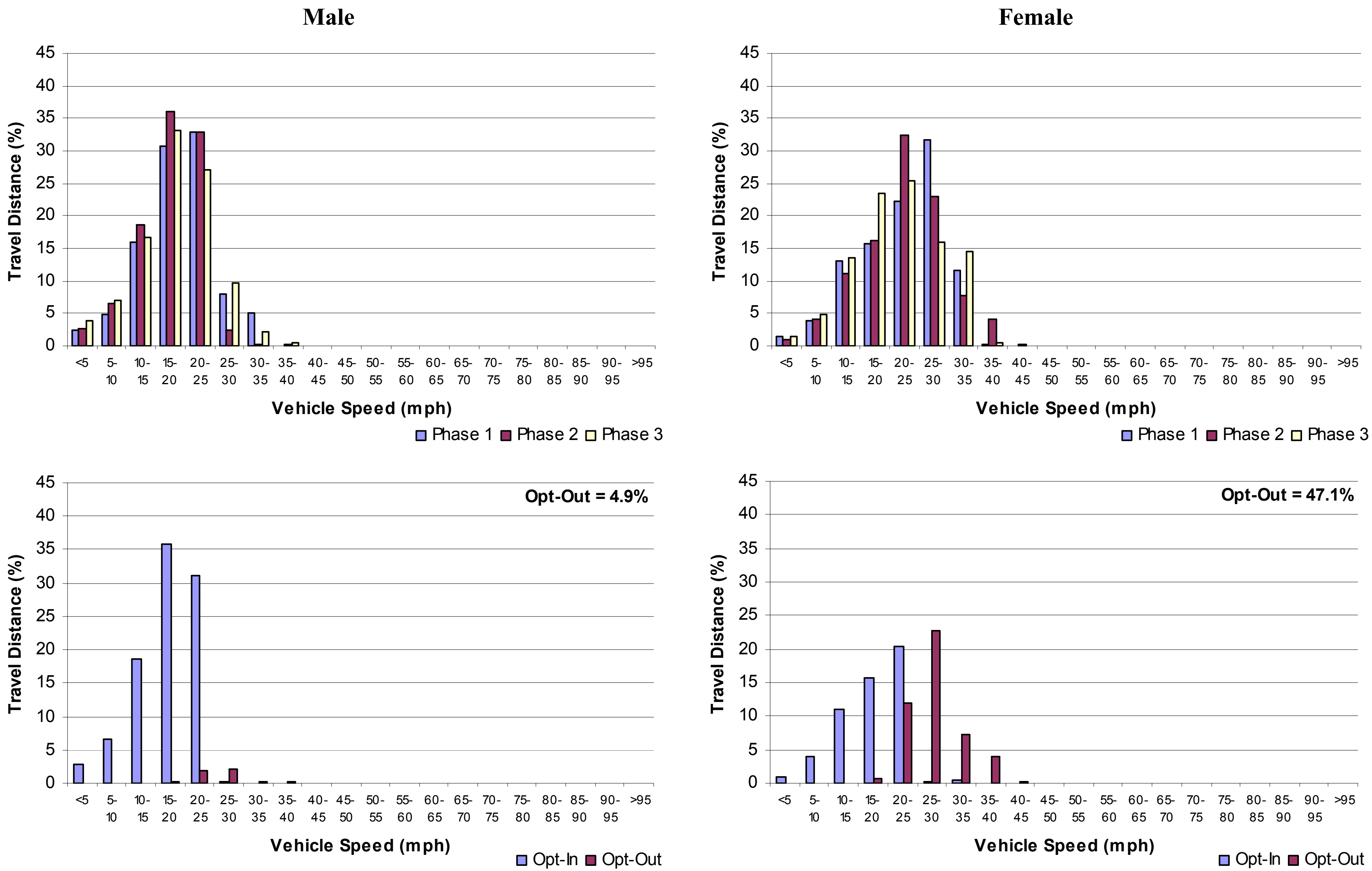



**Figure 16: Comparison of the speed distribution in 20 mph zones by gender**

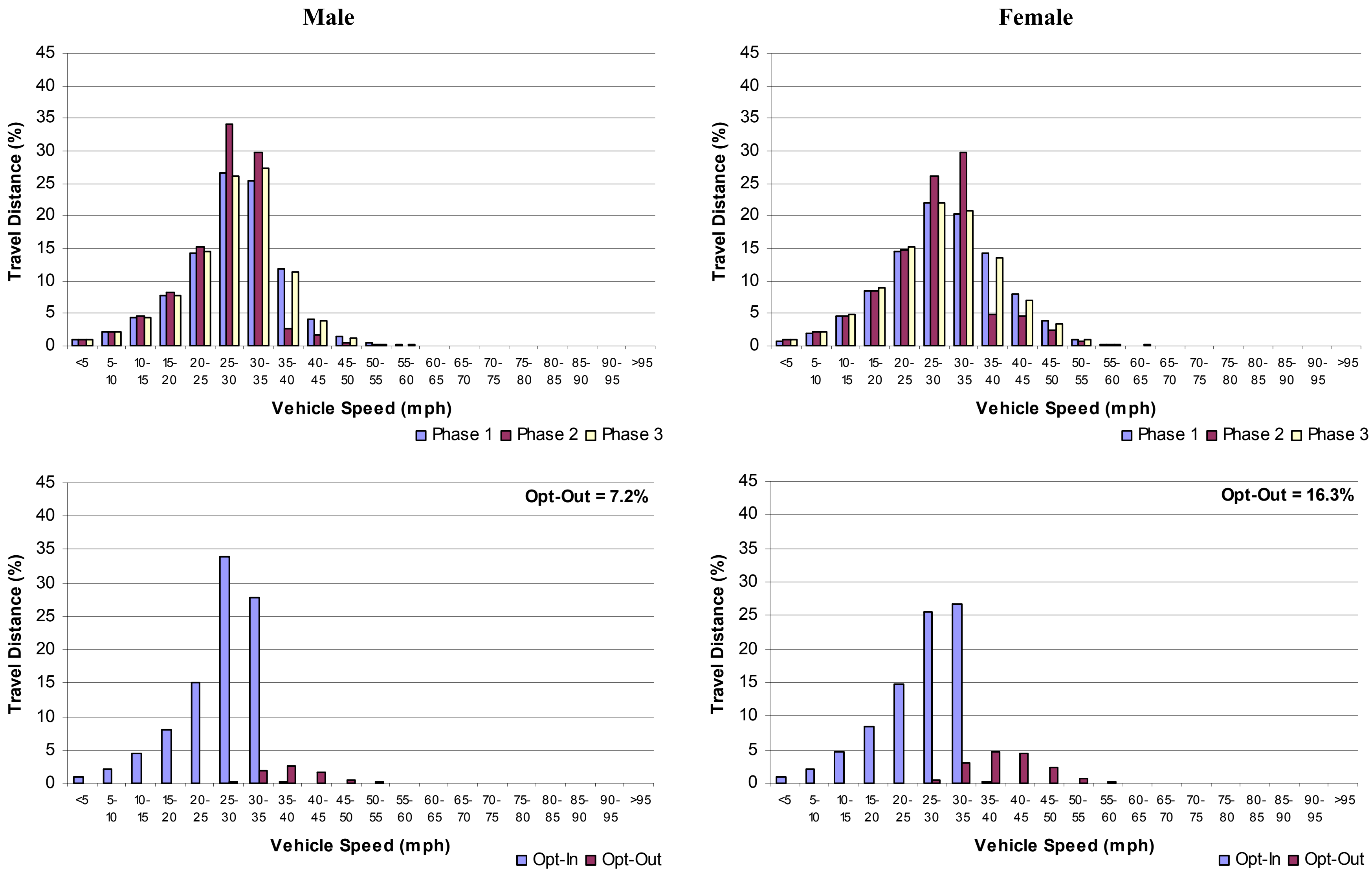



**Figure 17: Comparison of the speed distribution in 30 mph zones by gender**

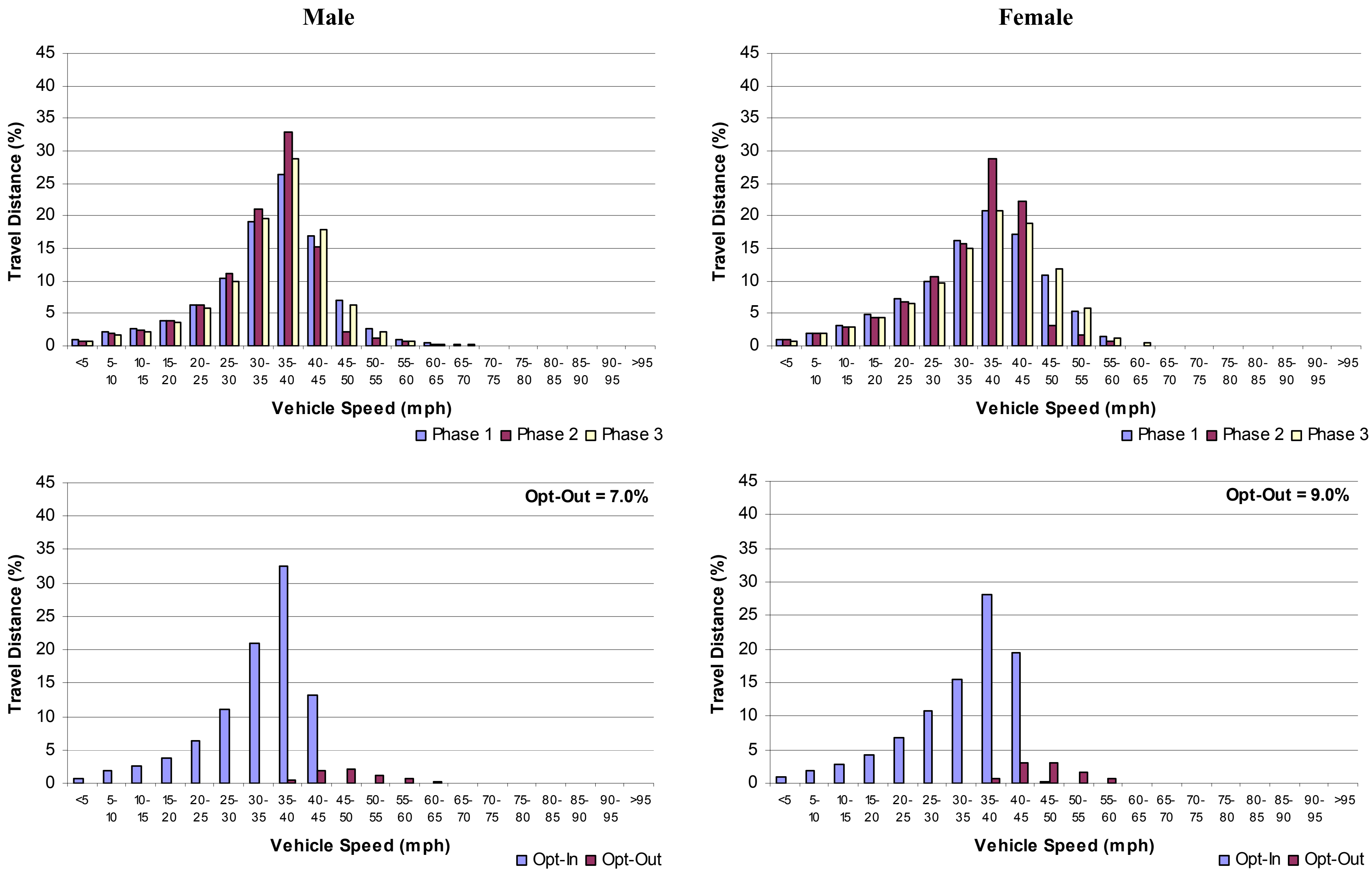



**Figure 18: Comparison of the speed distribution in 40 mph zones by gender**

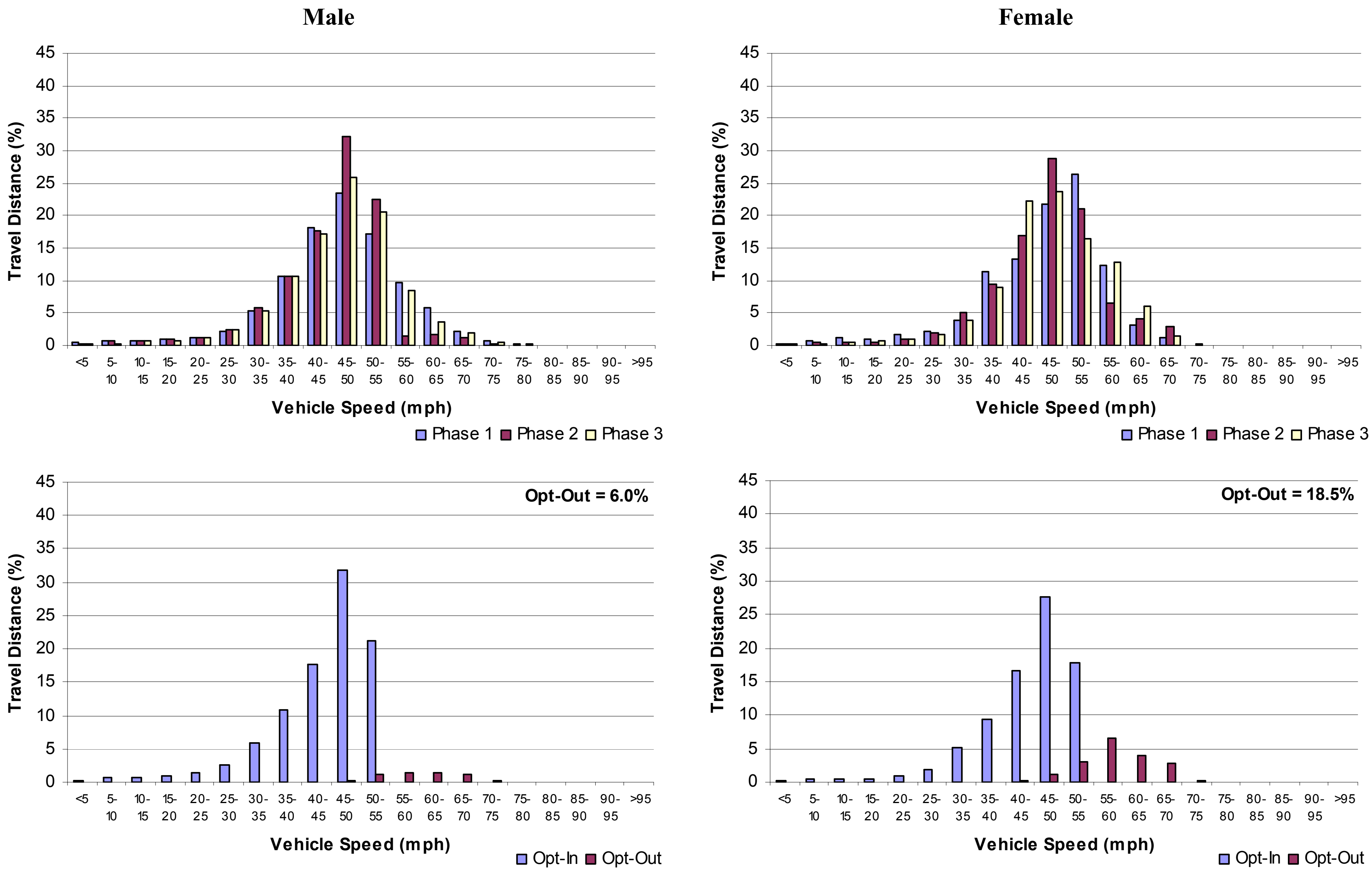



**Figure 19: Comparison of the speed distribution in 50 mph zones by gender**

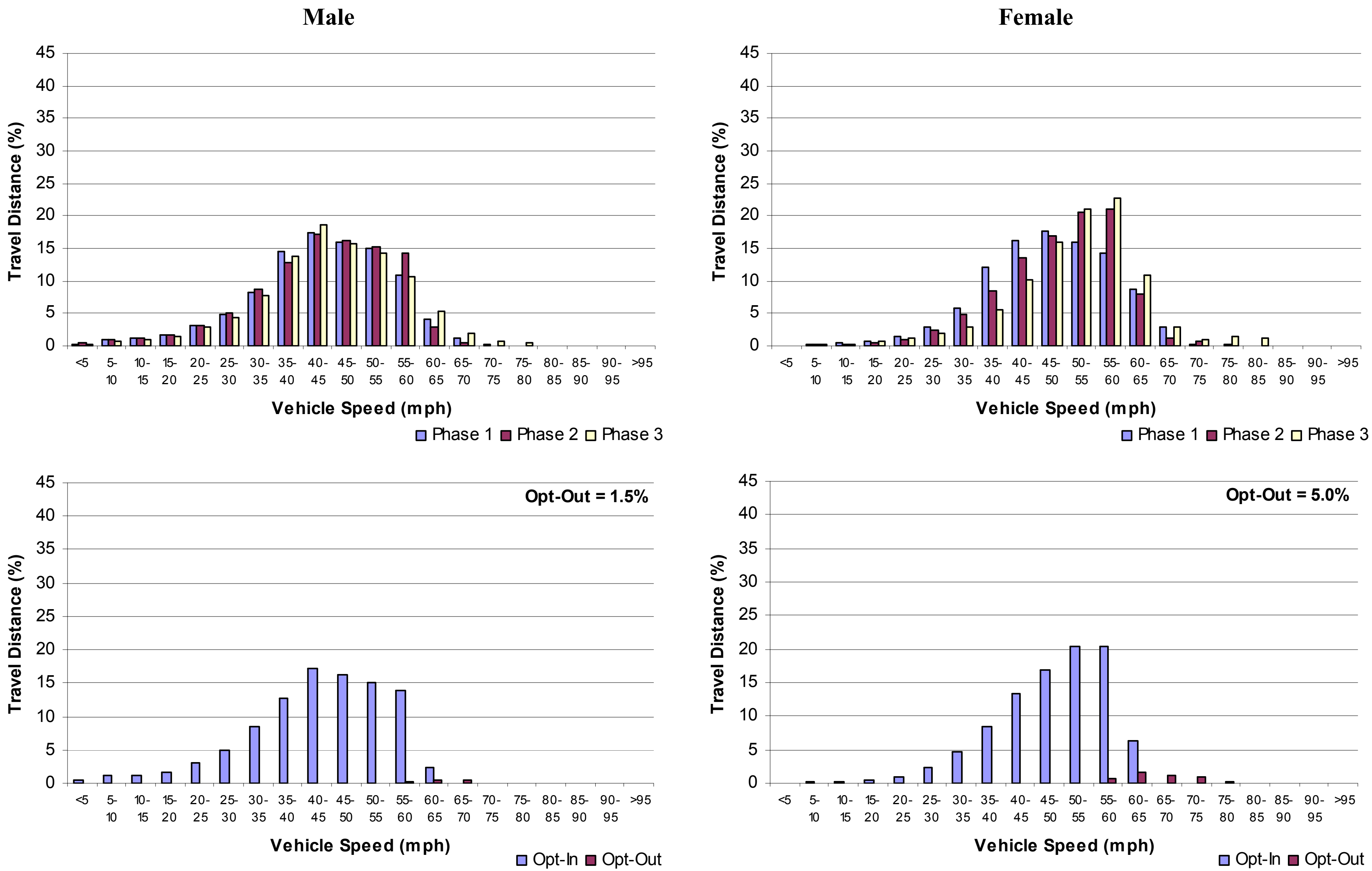



**Figure 20: Comparison of the speed distribution in 60 mph zones by gender**

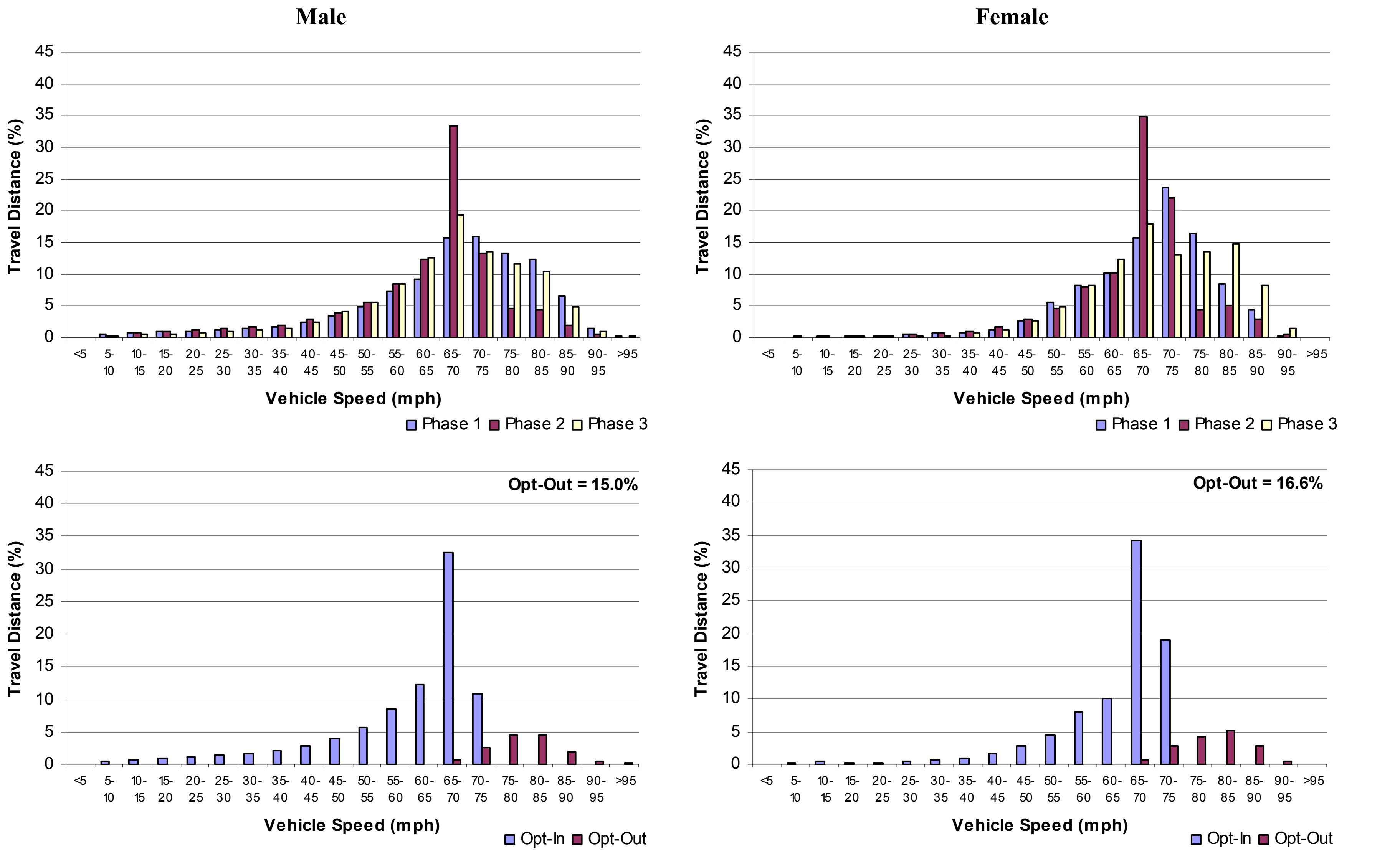



**Figure 21: Comparison of the speed distribution in 70 mph zones by gender**

Figure 22 compares the mean and the 85th percentile across trial phases in each speed zone between the two gender groups. ISA led to a reduction in vehicle speed across speed zones and gender groups, apart from the 60 mph zones. As explained earlier, the slight distortion shown in the 60 mph zones was presumably attributable to differences in participants' reference for choice of speed across trial phases. In addition, female participants generally demonstrated slightly higher mean and 85th percentile across speed zones than male participants, which was attributable to the biased female samples explained earlier.

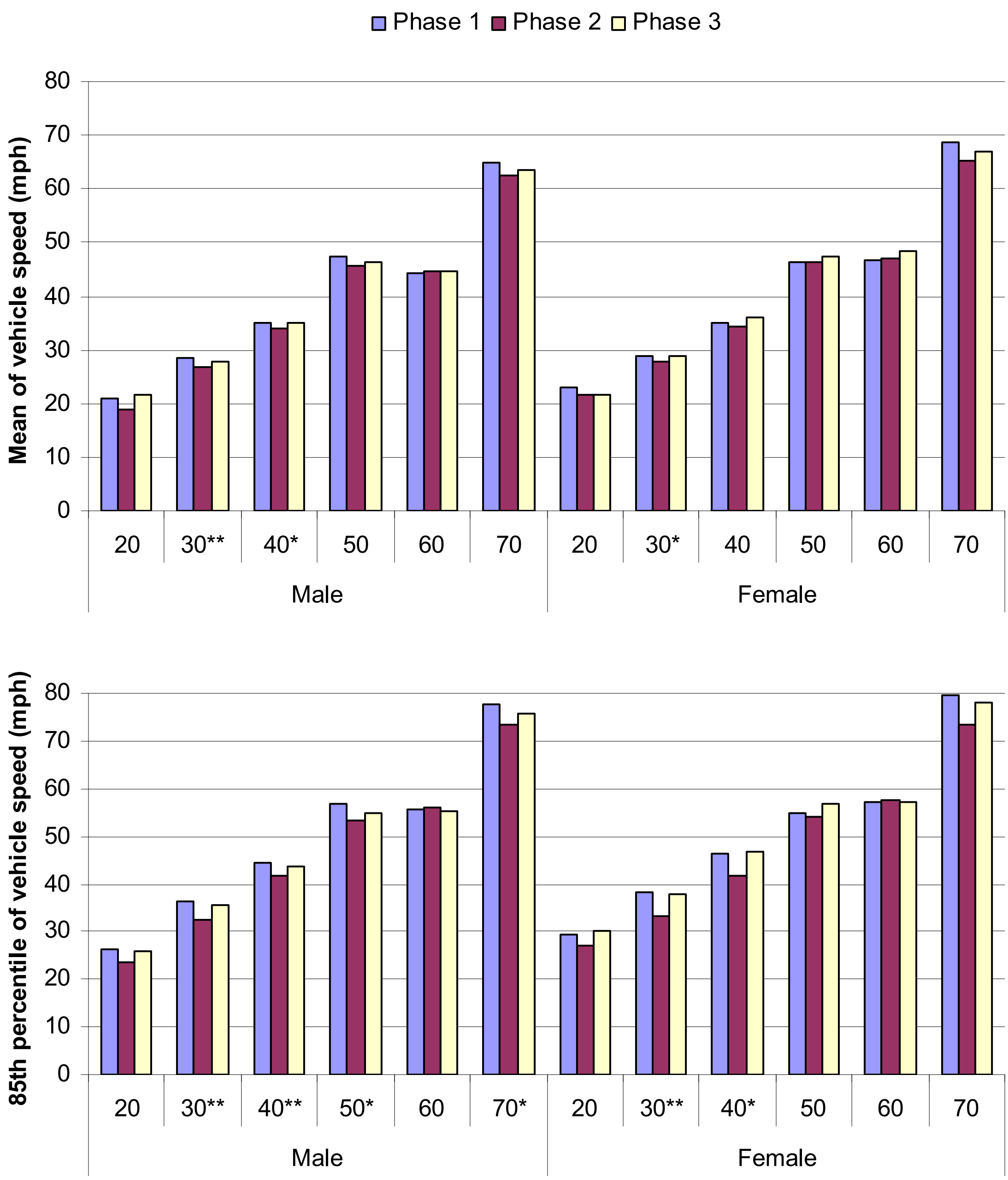



**Figure 22: Comparison of key statistics of the speed distribution across trial phases by gender**

A series of repeated measures ANOVAs were carried out to confirm the difference across trial phases in individual speed zones; significant results are annotated in Figure 22 but detailed test results are given in Appendix B. It is worth noting that the male group appeared to have led to significant test results in more speed zones than the female group, which was attributable to the imbalanced sample size in the gender groups (i.e. 3 against 17).

### 3.5.2 Age

Table 19 depicts a breakdown of vehicle kilometres across trial phases, speed zones and participants' age groups, which shows that older participants contributed longer travel distance than younger participants. Figure 23 further compares the distribution of travel distance between the two age groups. The patterns of travel distance were very similar across the two age groups.

**Table 19: Vehicle kilometres across trial phases, speed zones and age groups**

| Speed zone | Young | | | Old | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 1 | Phase 2 | Phase 3 |
| 20 mph | 8 | 35 | 16 | 22 | 45 | 12 |
| 30 mph | 2,981 | 7,759 | 3,584 | 5,275 | 15,969 | 3,993 |
| 40 mph | 1,843 | 4,802 | 1,760 | 2,521 | 7,626 | 2,143 |
| 50 mph | 684 | 1,652 | 732 | 923 | 3,029 | 818 |
| 60 mph | 734 | 2,084 | 803 | 1,535 | 4,813 | 1,232 |
| 70 mph | 3,277 | 8,142 | 3,789 | 5,446 | 12,509 | 3,339 |
| Sum | 44,687 | | | 71,250 | | |

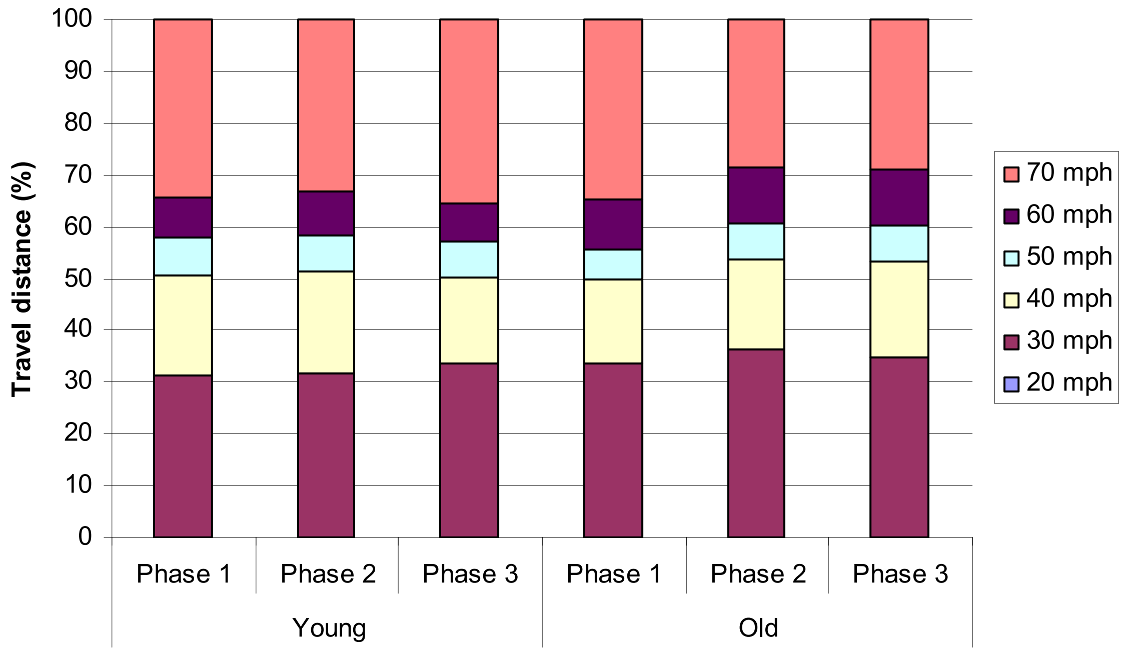



**Figure 23: Comparison of patterns of travel distance between age groups**

Figure 24 through Figure 29 compare speed distribution across trial phases between the two age groups. ISA effectively reshaped the speed distribution for both groups across speed zones but younger participants were observed to have overridden the system more frequently than older participants across all speed zones, apart from the 40 mph zones.

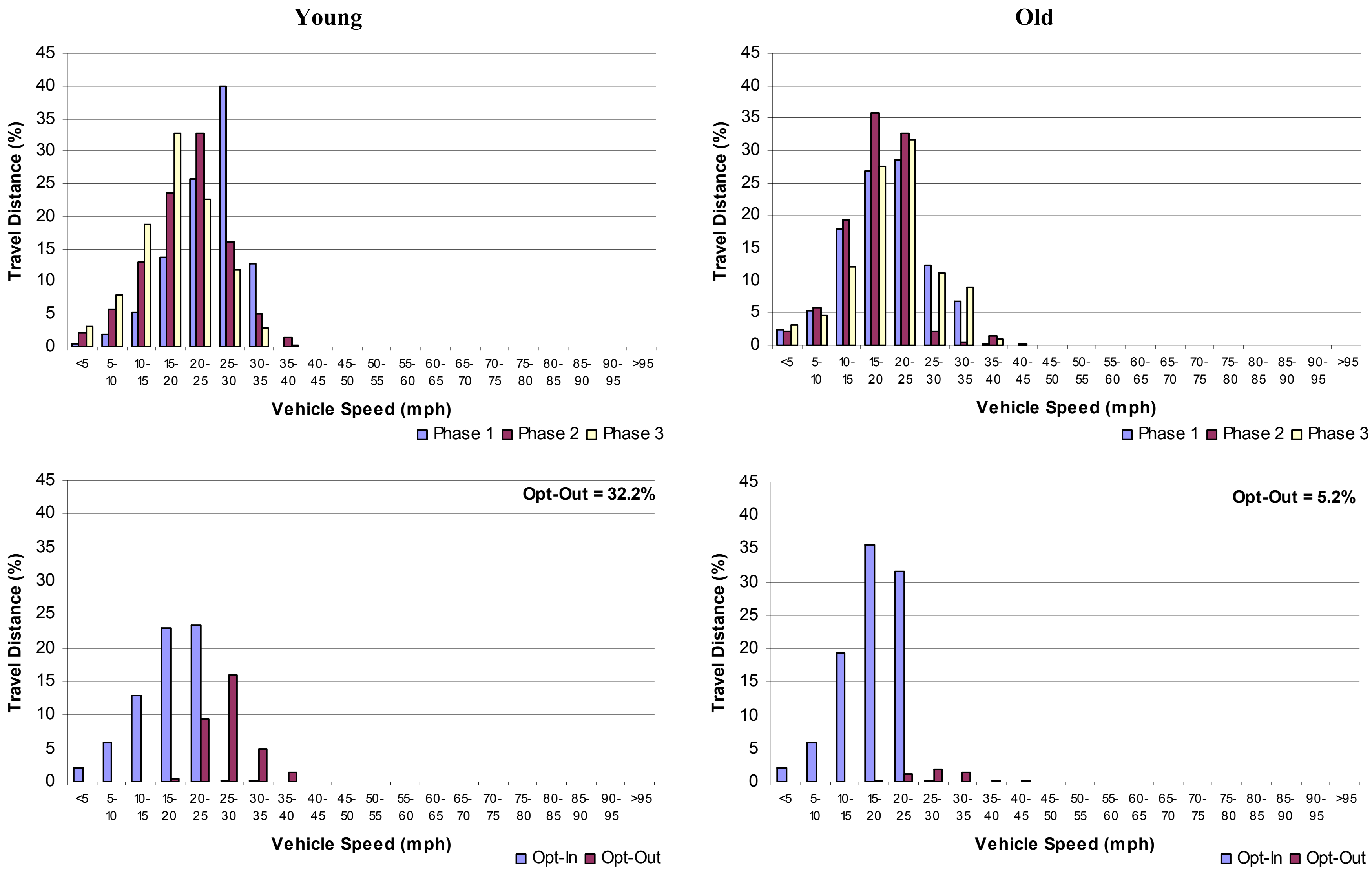



**Figure 24: Comparison of the speed distribution in 20 mph zones between age groups**

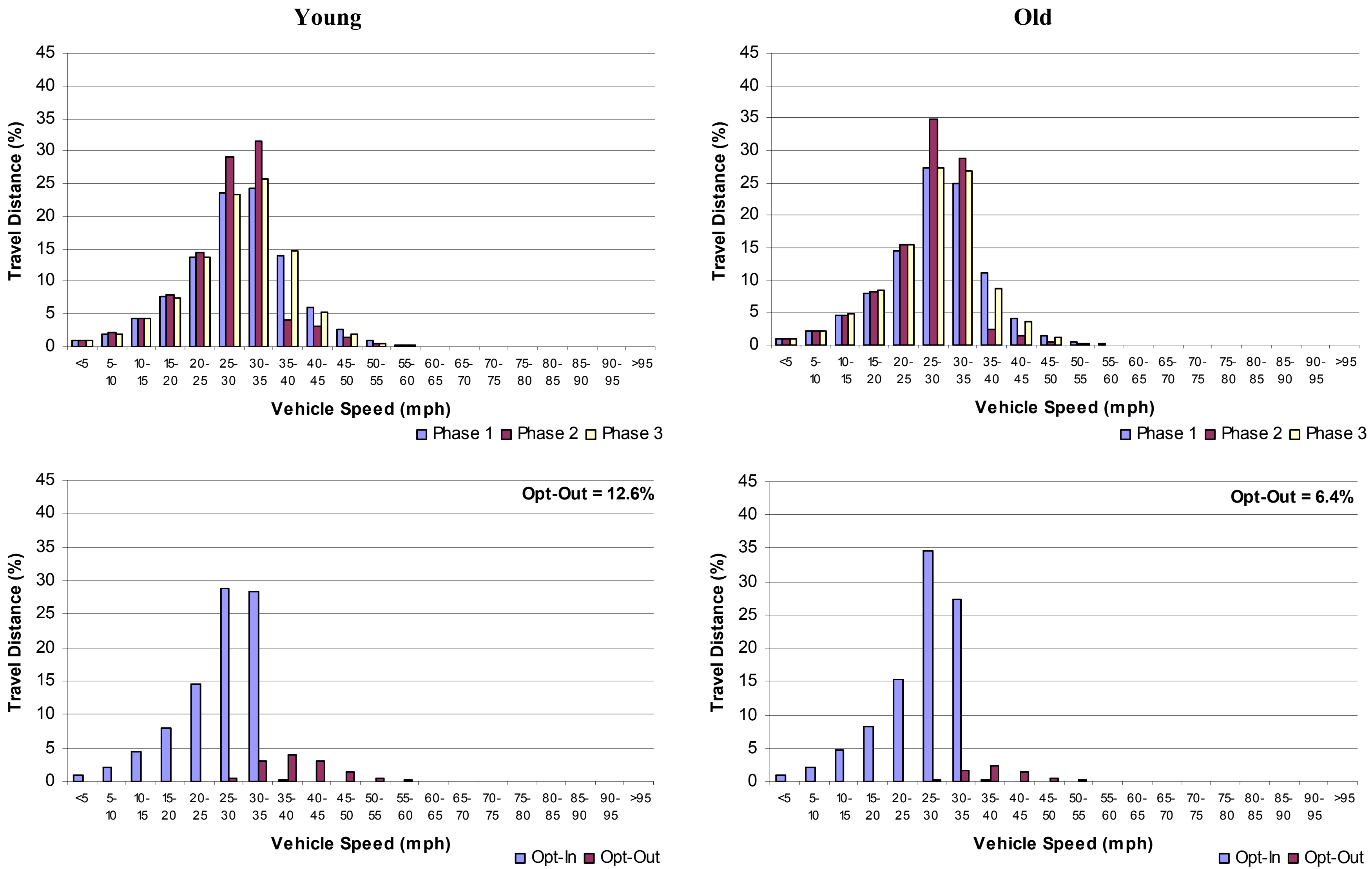



**Figure 25: Comparison of the speed distribution in 30 mph zones between age groups**

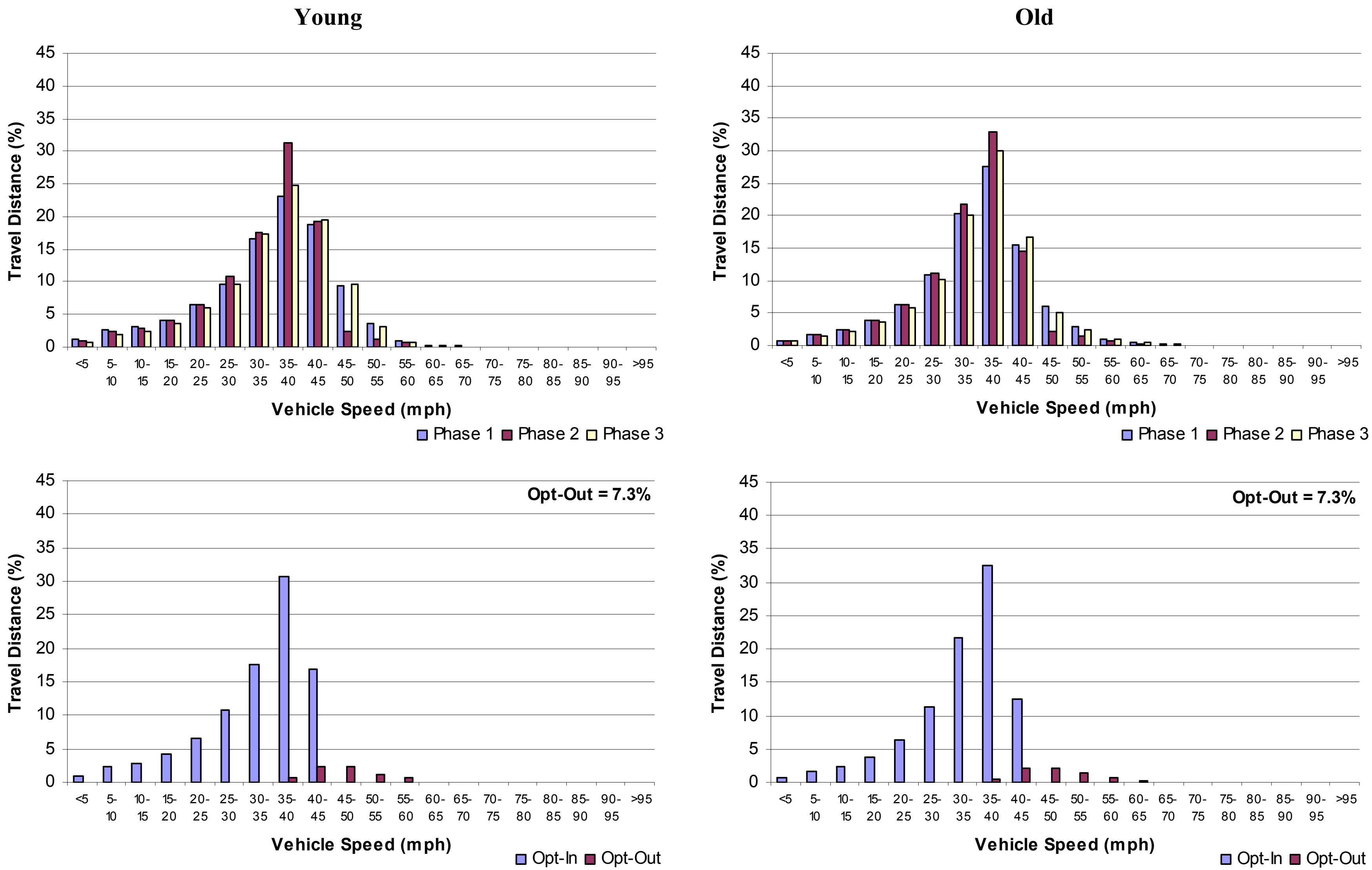



**Figure 26: Comparison of the speed distribution in 40 mph zones between age groups**

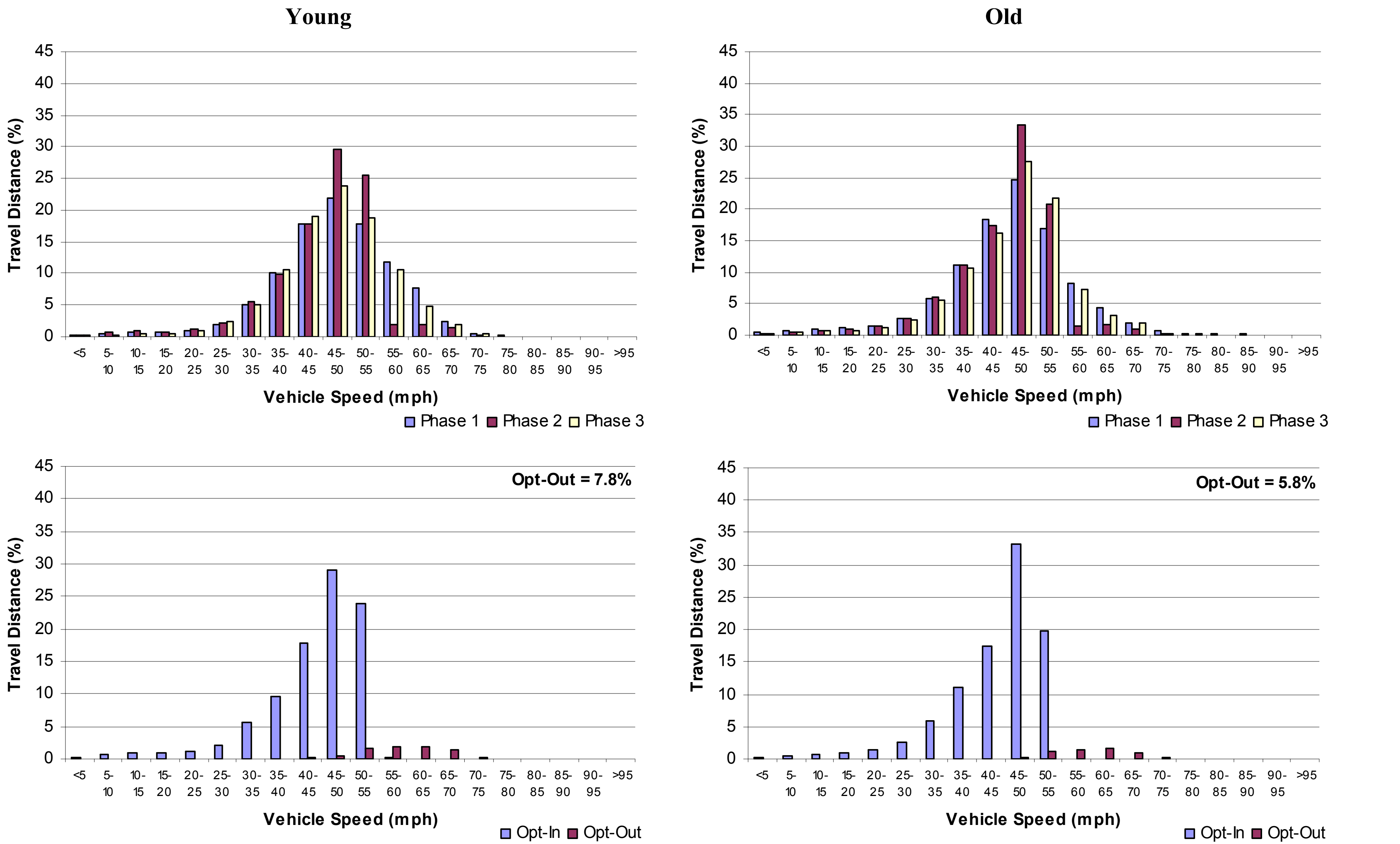



**Figure 27: Comparison of the speed distribution in 50 mph zones between age groups**

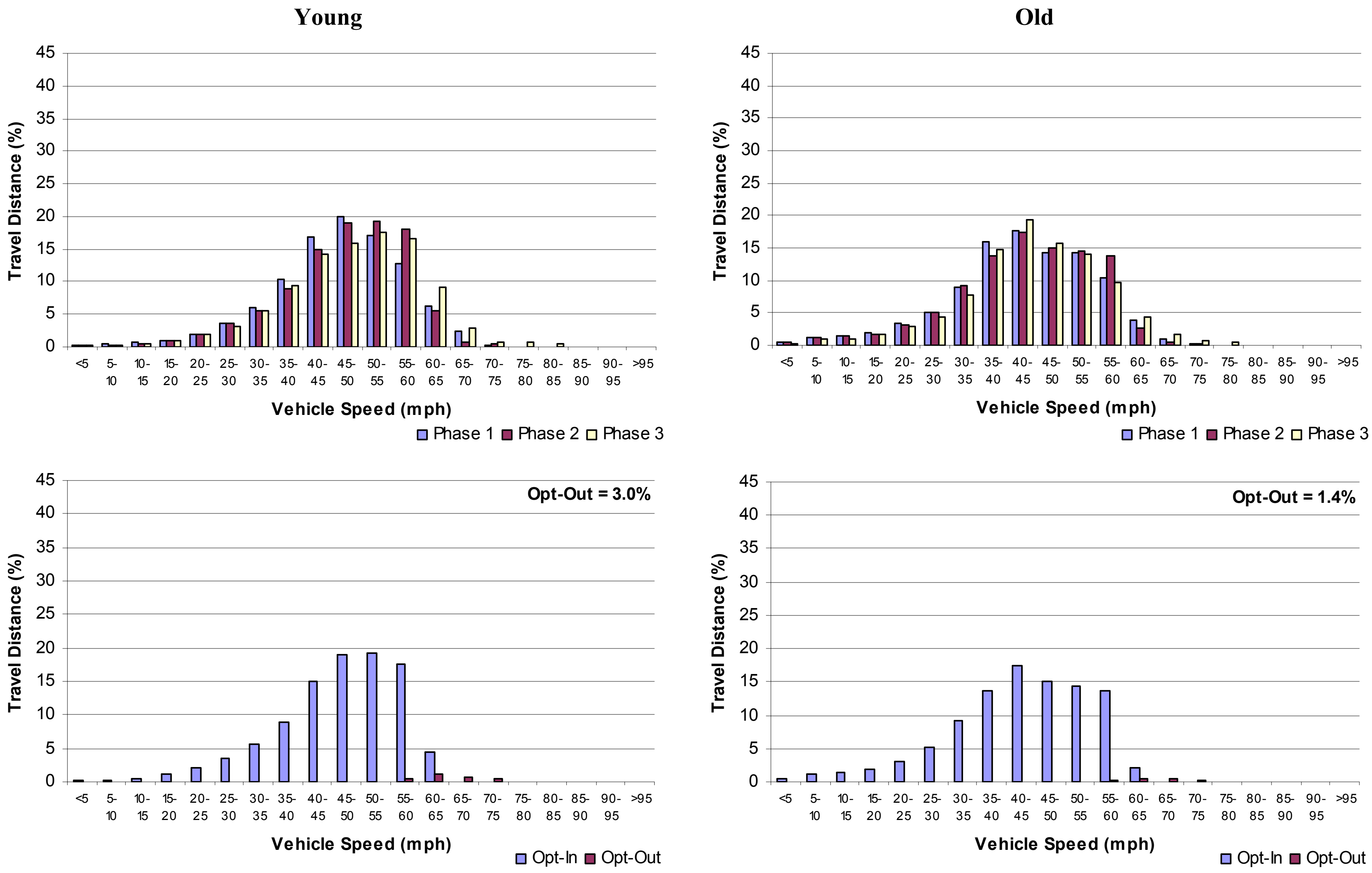



**Figure 28: Comparison of the speed distribution in 60 mph zones between age groups**

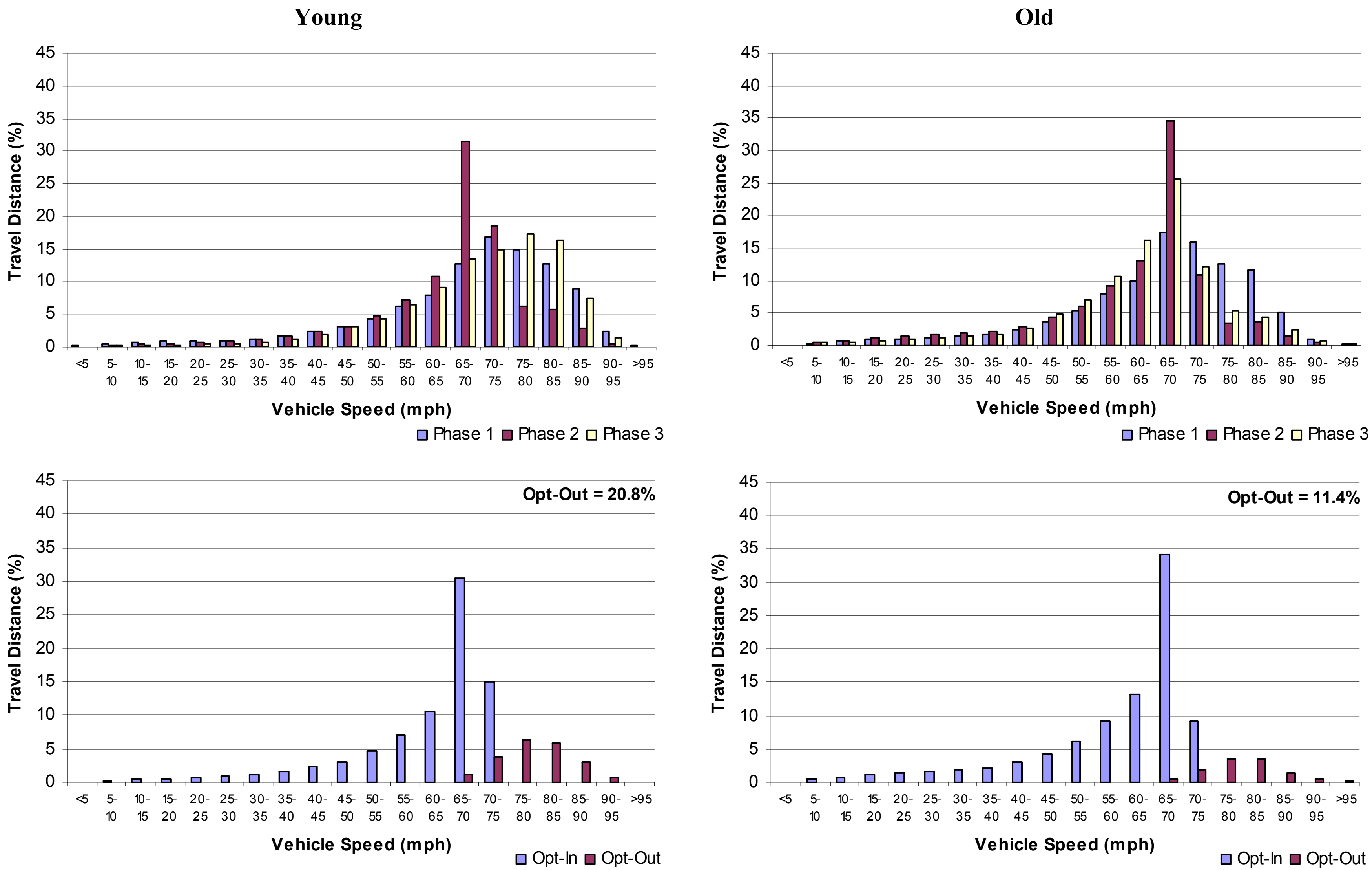



**Figure 29: Comparison of the speed distribution in 70 mph zones between age groups**

Figure 30 compares the mean and the 85th percentile across trial phases in each speed zone between the two age groups. Again as previously observed, ISA led to a 'V' shape across speed zones and gender groups, apart from the usual distortion in the 60 mph zones. In addition, these comparisons suggest that younger participants generally demonstrated slight higher mean speeds and higher 85th percentiles.

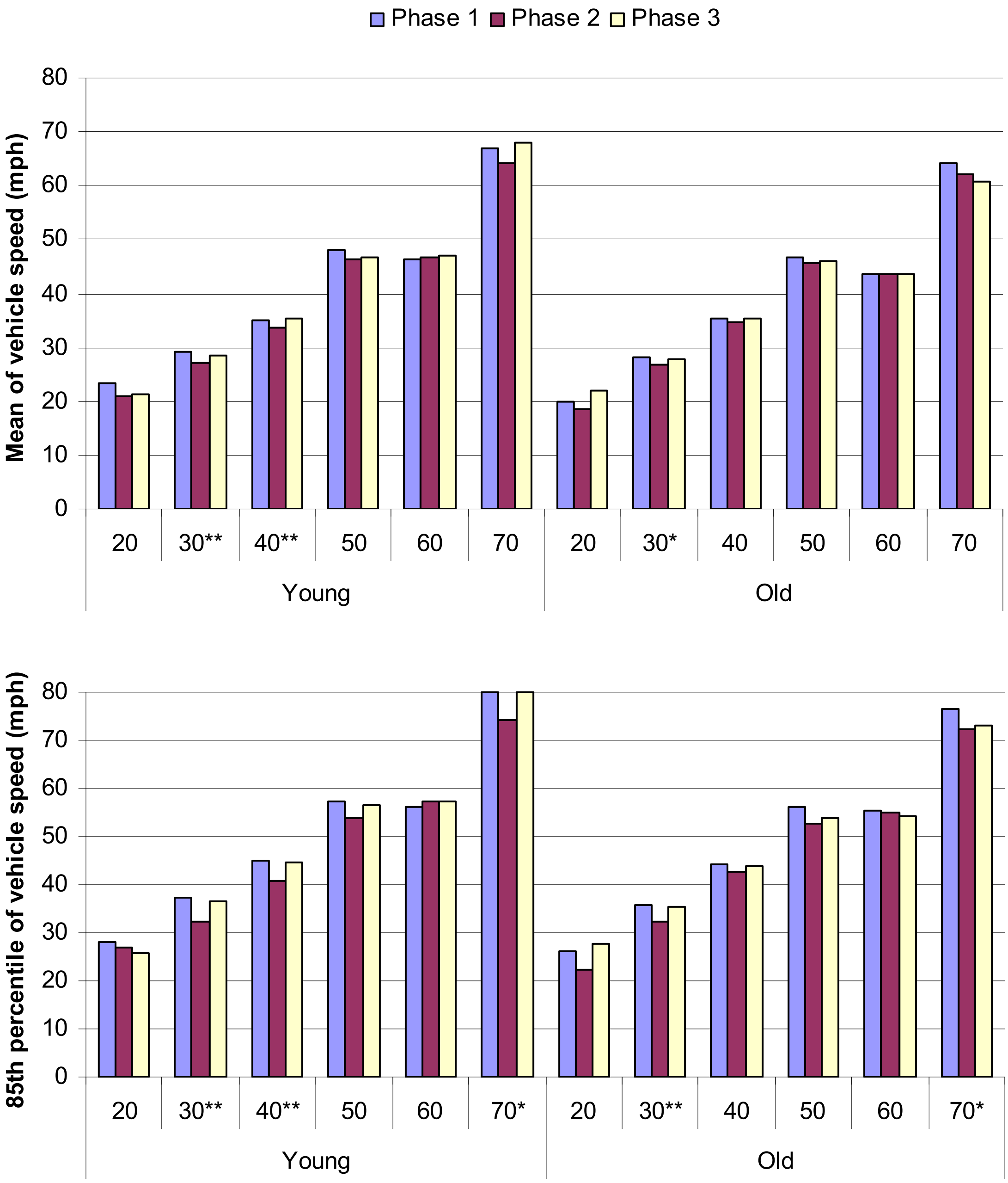



**Figure 30: Comparison of key statistics of the speed distribution across trial phases between age groups**

A series of repeated measures ANOVAs were carried out to confirm the difference across trial phases in individual speed zones; significant results are annotated in Figure 30 while detailed test results are given in Appendix B. ISA appeared to have a greater effect on younger participants, especially in the urban areas.

### 3.5.3 Intention to speed

Table 20 depicts a breakdown of vehicle kilometres across trial phases, speed zones and participants' intention to speed, which shows that intenders contributed longer travel distance than non-intenders. This however may be partially attributable to the imbalanced sample size as depicted in Table 17 (i.e. 12 intenders against 8 non-intenders). Figure 31 further compares the distribution of travel distance between the two groups, and reveals similar travel patterns across the two groups of participants. Both groups drove most frequently in the 30 and 70 mph zones but intenders spent a larger proportion of their travel distance in the 70 mph zones in comparison with non-intenders.

**Table 20: Vehicle kilometres across intention groups, trial phases and speed zones**

| Speed zone | Intender | | | Non intender | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 1 | Phase 2 | Phase 3 |
| 20 mph | 24 | 56 | 15 | 6 | 25 | 13 |
| 30 mph | 5,385 | 15,705 | 4,647 | 2,871 | 8,023 | 2,931 |
| 40 mph | 2,799 | 7,915 | 2,453 | 1,565 | 4,514 | 1,450 |
| 50 mph | 970 | 2,590 | 842 | 637 | 2,092 | 708 |
| 60 mph | 1,568 | 4,792 | 1,371 | 701 | 2,105 | 664 |
| 70 mph | 6,065 | 13,175 | 5,063 | 2,658 | 7,476 | 2,065 |
| Sum | 75,433 | | | 40,503 | | |

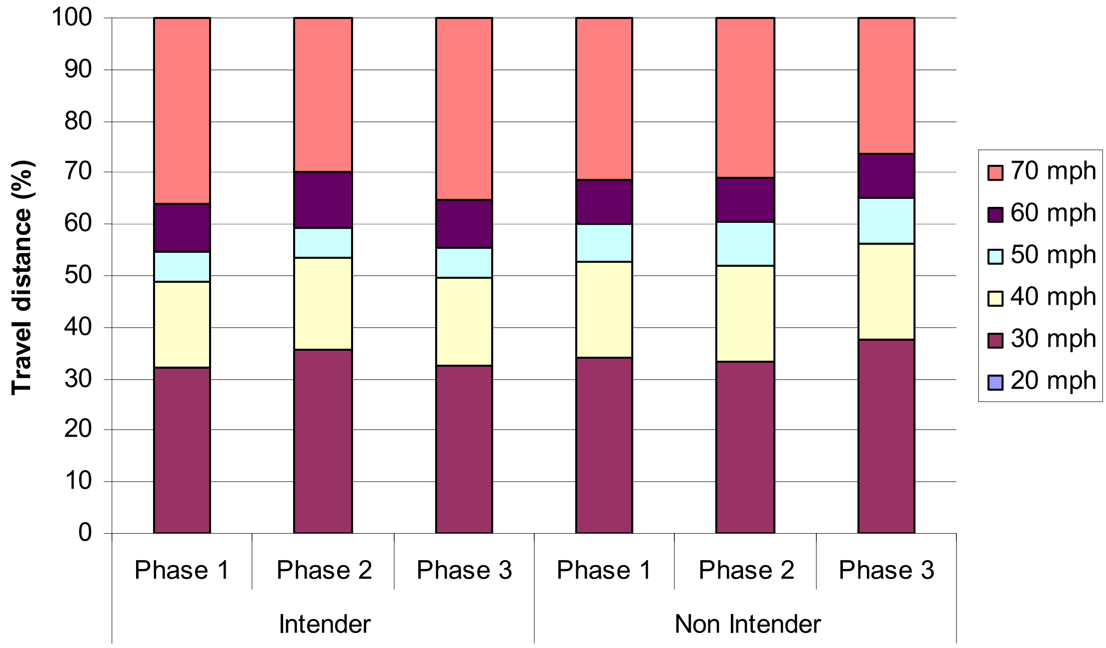



**Figure 31: Comparison of patterns of travel distance between intention groups**

Figure 32 through Figure 37 compare speed distribution across trial phases between the two intention groups. ISA effectively reshaped the speed distribution for both groups across speed zones but intenders were observed to have overridden the system more frequently than non-intenders across all speed zones, apart from the 60 mph zone.

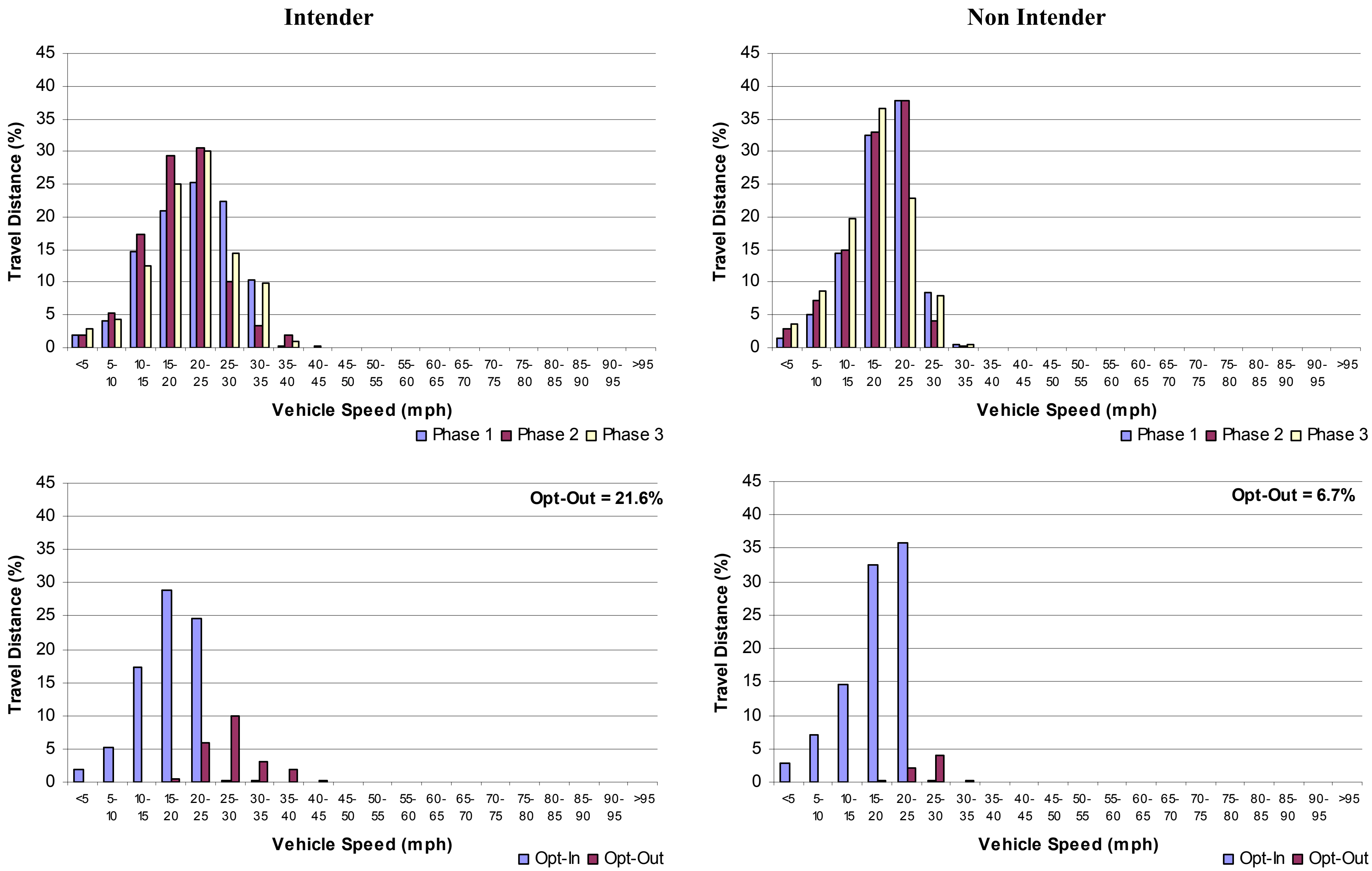



**Figure 32: Comparison of the speed distribution in 20 mph zones between intention groups**

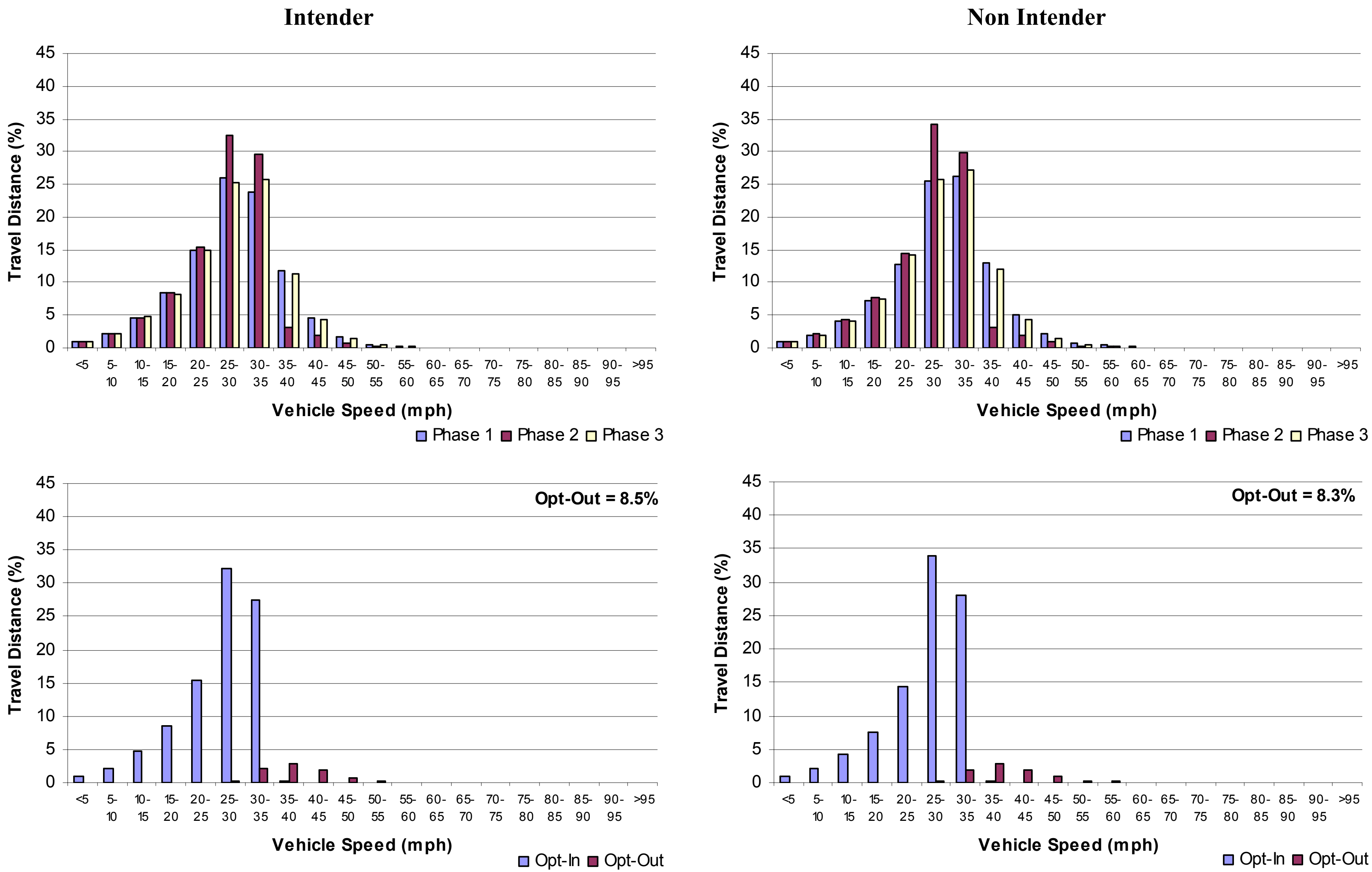



**Figure 33: Comparison of the speed distribution in 30 mph zones between intention groups**

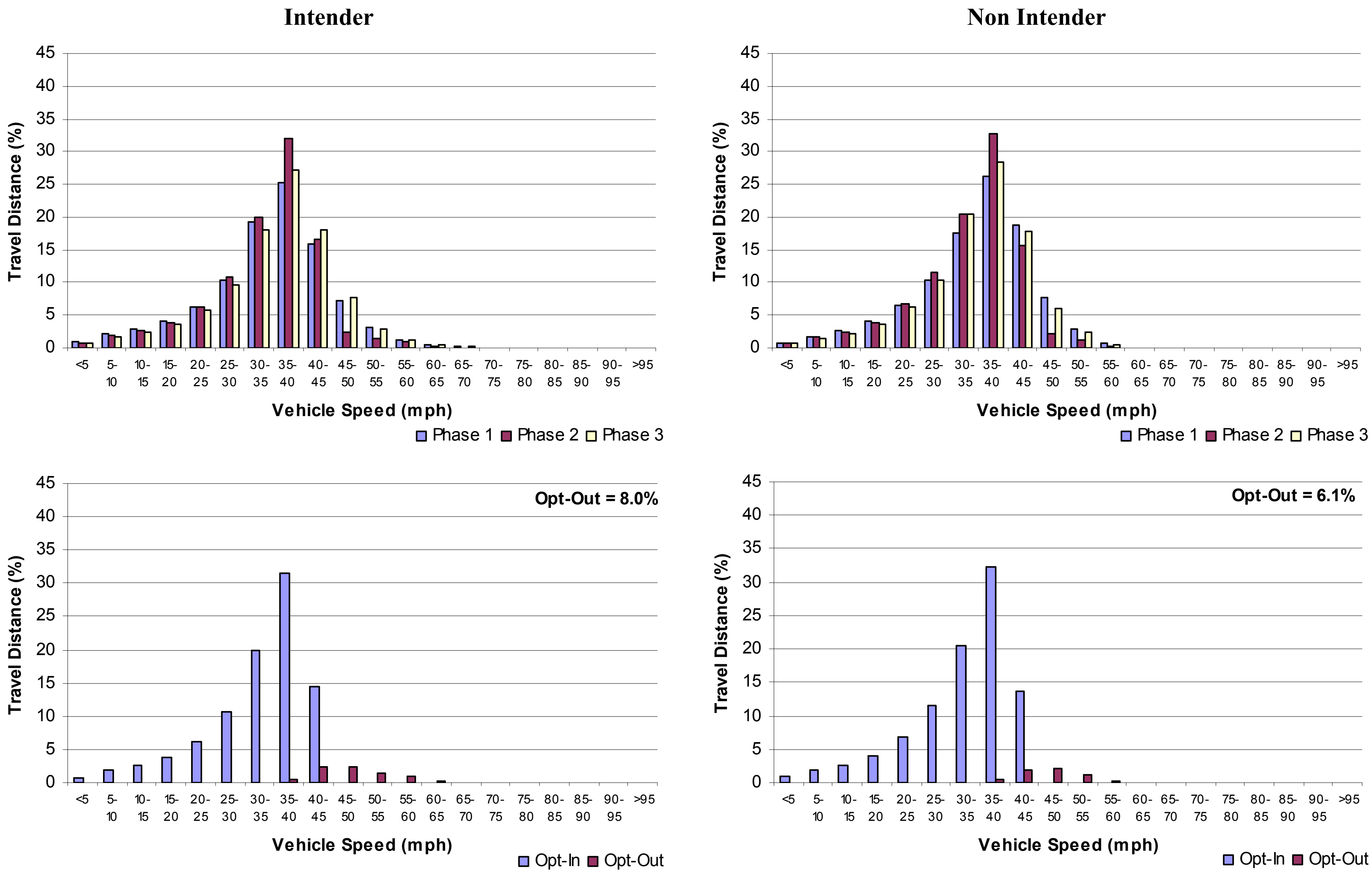



**Figure 34: Comparison of the speed distribution in 40 mph zones between intention groups**

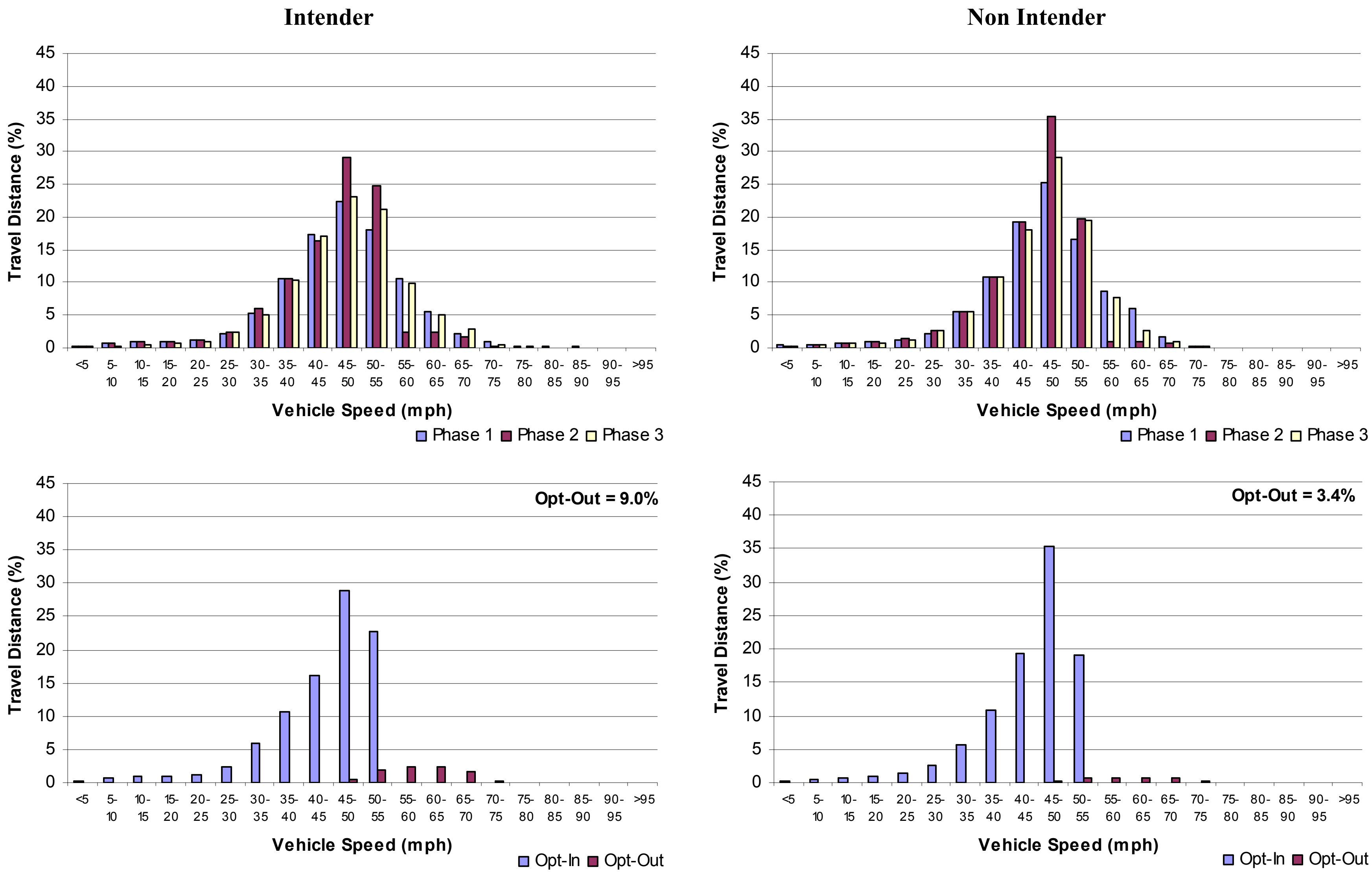



**Figure 35: Comparison of the speed distribution in 50 mph zones between intention groups**

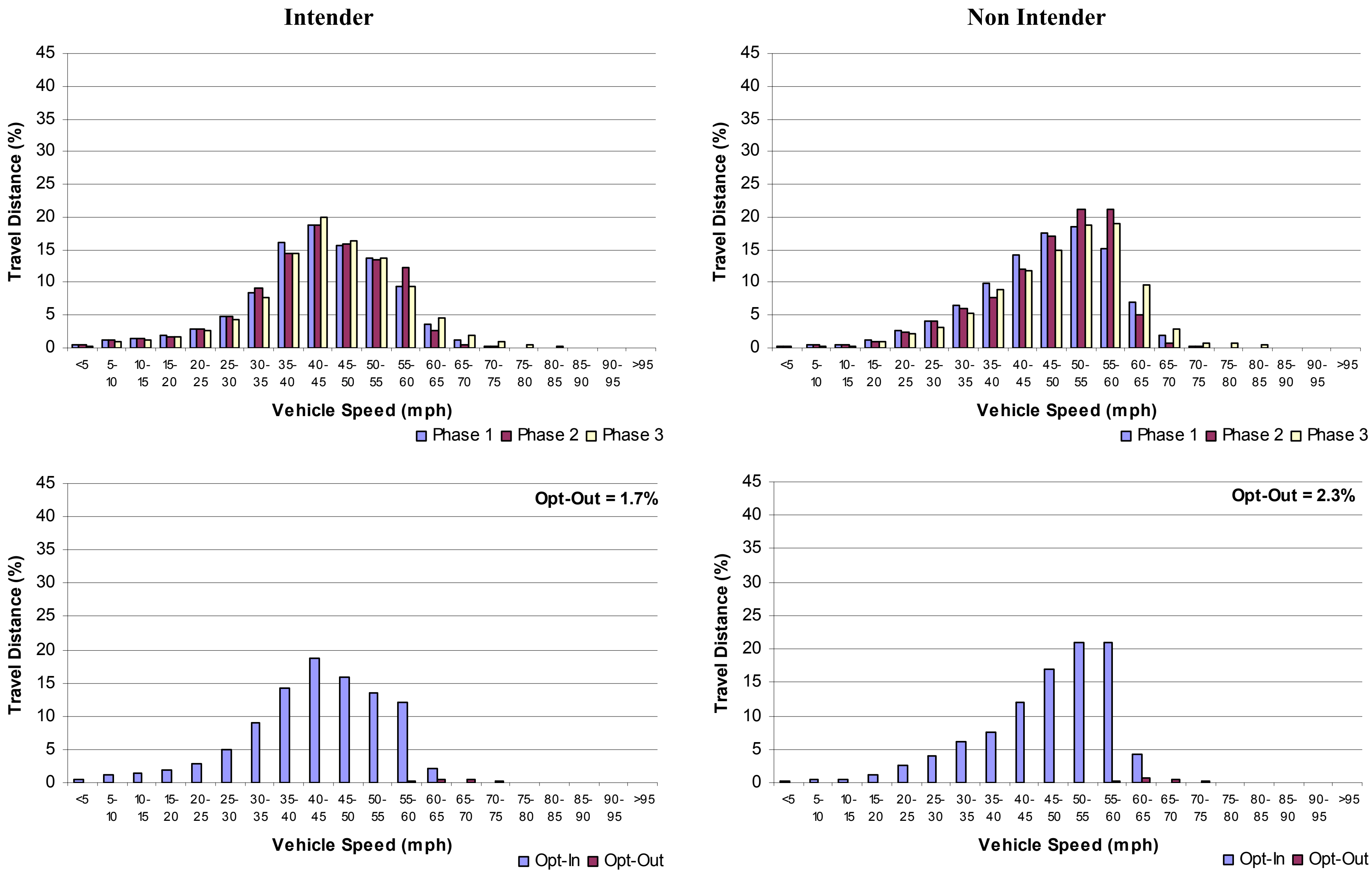



**Figure 36: Comparison of the speed distribution in 60 mph zones between intention groups**

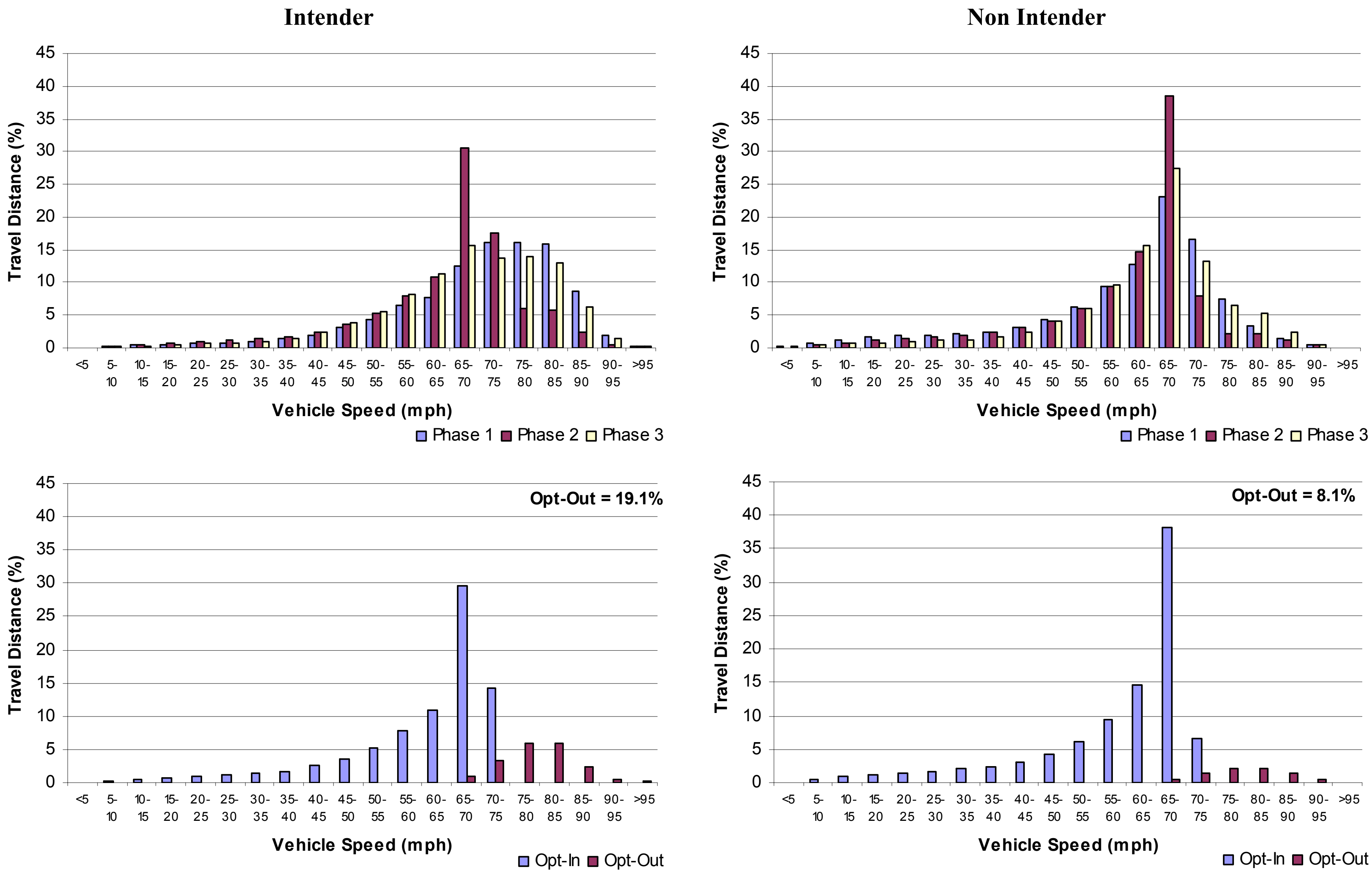



**Figure 37: Comparison of the speed distribution in 70 mph zones between intention groups**

Figure 38 compares the mean and the 85th percentile across trial phases in each speed zone between the two intention groups of participant. ISA led to a 'V' shape across speed zones and intention groups, apart from the usual distortion in the 60 mph zones and the mean speed derived from non-intenders in the 50 mph zones. In addition, these comparisons suggest that intenders generally demonstrated slight higher mean speeds and higher 85th percentiles.

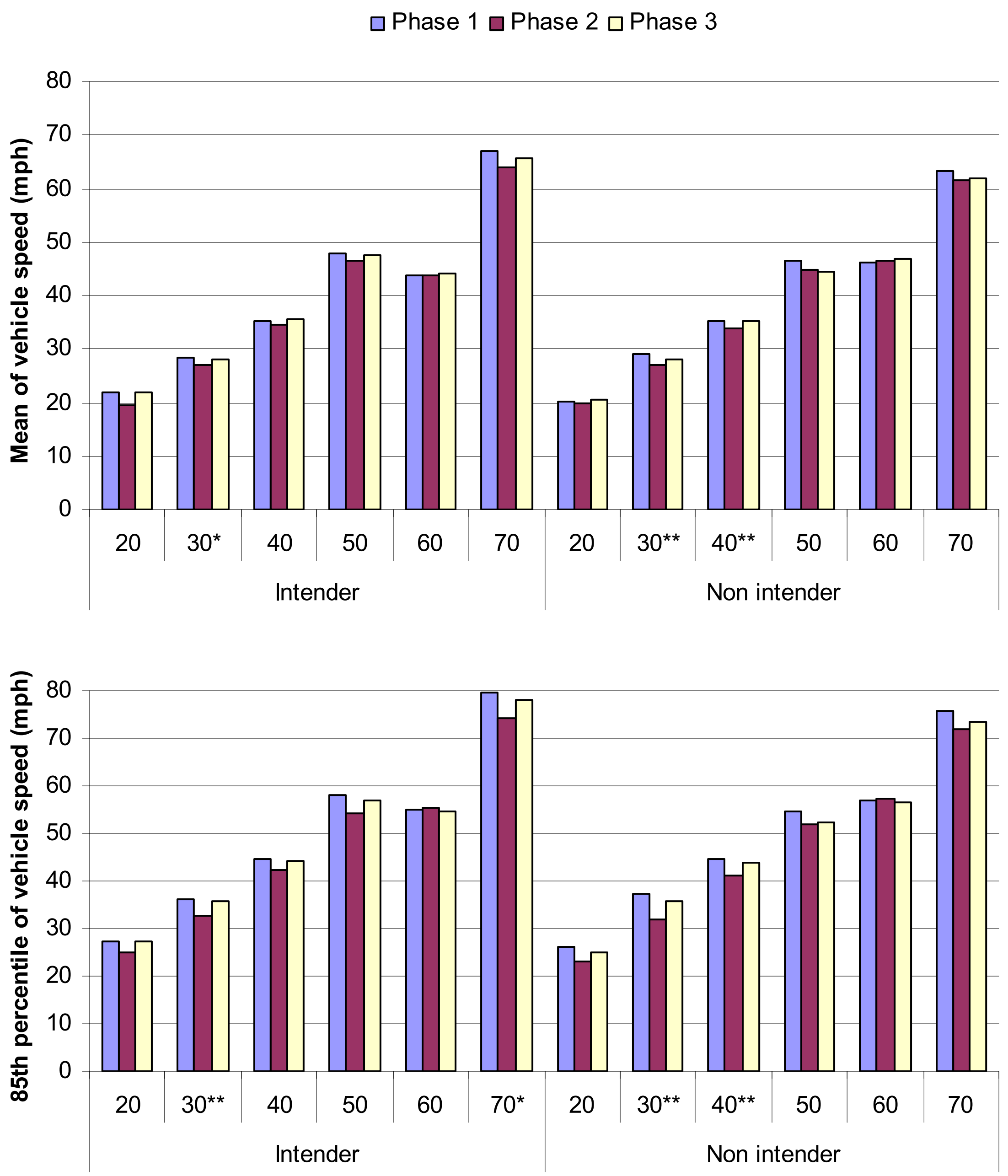



**Figure 38: Comparison of key statistics of the speed distribution across trial phases between intention groups**

A series of repeated measures ANOVA were carried out to confirm the differences across trial phases in individual speed zones; significant results are annotated in Figure 38 although detailed test results are given in Appendix B. As shown in Figure 38, ISA seemed to have a greater effect on non-intenders especially within lower speed zones.

### 3.5.4 The effect of ISA on demographic groups

As presented in the previous three sections, ISA intervention influenced the shape of the speed distribution across demographic groups and led to a 'V' shape on comparison of key statistics across trial phases in most of the speed zones.

Overriding behaviours were clearly distinguishable across speed zones with respect to each pair of demographic groups. Figure 39 compares participants' overriding behaviour in general, regardless of speed zones, and highlights that younger drivers and intenders overrode the ISA system more than their counterparts. As the comparison between gender groups was considered to be distorted by biased samples, it is therefore excluded from Figure 39.

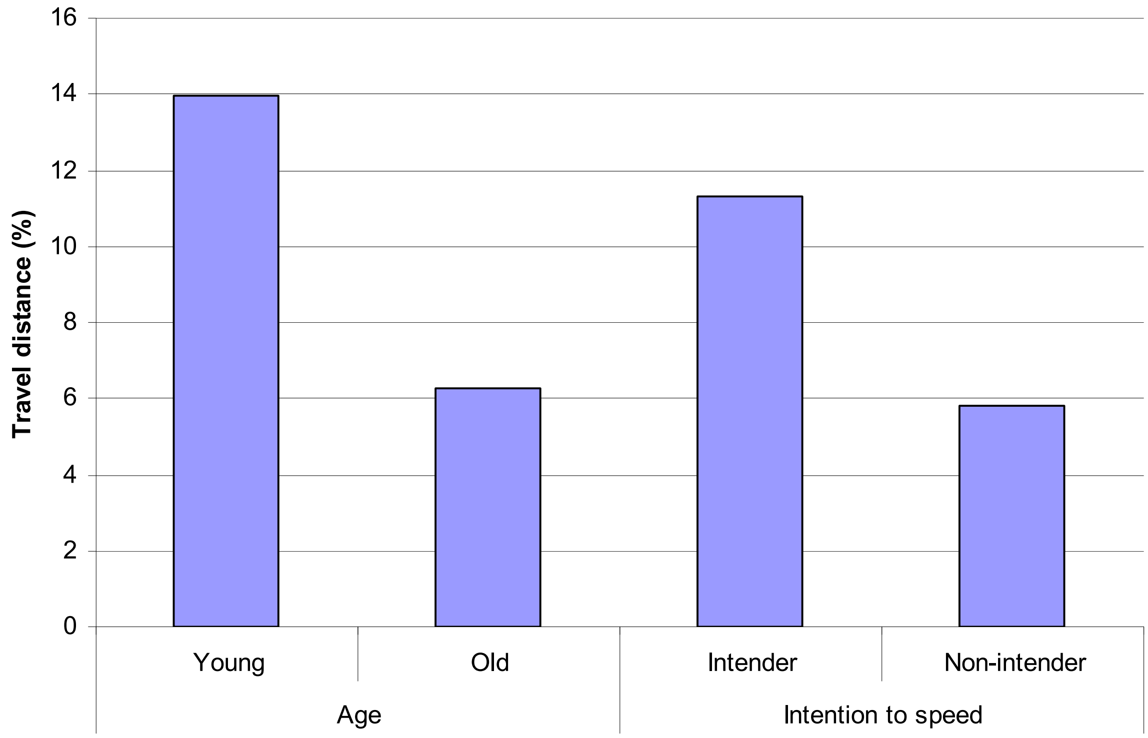



**Figure 39: Comparison of overriding behaviour across demographic groups**

Considering that the young and intender groups also demonstrated slightly higher mean and 85th percentile values of speed distribution than their counterparts (i.e. Figure 30 in Section 3.5.2 and Figure 38 in Section 3.5.3), it seems that ISA was overridden by those drivers who need it most. The effectiveness of the ISA system would therefore be enhanced if compliance within the young and intender groups is encouraged and improved.

## 3.6 Discussion

Based on the analyses presented in this chapter, the ISA system leads to a distinctive effect in terms of transformation of the speed distribution. When ISA was switched on, a large proportion of the speed distribution initially spread over the speed limits was shifted to around or below the speed limit.

Most participants were observed to have adapted their reference for their chosen speed between trial phases. During Phase 1 and 3 when the ISA system was turned off, many participants were observed to obey the speed limits with reference to the speedometer reading. During Phase 2, most participants were observed to rely on the ISA system (i.e. throttle feedback) instead of the speedometer reading. This caused a slight distortion in Phase 2 that some data cluster within the higher speed band immediately next to the legal speed limits. Nevertheless, the trial results undoubtedly demonstrate the effectiveness of the ISA system on reshaping speed distribution.

The changes in speed distribution as a result of ISA intervention were confirmed by statistical test results. The results also indicate that ISA intervention was more effective in reducing excessive speed than mean speed. This is demonstrated by larger effect sizes derived from the 85$^{th}$ percentiles than from the mean speeds across speed zones. Since injury severity is related to speed reduction (Nilsson, 1981), the cut-down of excessive speed delivers promising implications to road safety.

The effect of ISA intervention on reshaping of the speed distribution was less prominent in the 60 mph zones, where speeding behaviour had already rarely been observed even in the absence of ISA. This is primarily due to the constrains on driving speed imposed by road geometry, as the 60 mph speed limit is applicable to most rural roads where the layout is usually single carriageway with a mixture of geometric profiles.

The ISA system not only stops excessive speeding, but also leads to a reduction in speed variability. The reduction in speed variability was in particular prominent in the urban area where speed limits are 30 or 40 mph, which promises positive implications to a reduction in accident occurrence, as speed variability is related to accident rate (Taylor et al, 2000).

The current design of an overridable system also highlights the value of a mandatory ISA system or incentives to encourage compliance with the ISA system. Moreover, it was revealed that younger drivers and drivers who intend to break speed limits overrode the system more often than older drivers and drivers with less intention to break speed limits. In addition, the gender differences derived from this trial were not regarded to be representative of the whole population due to the biased sample (i.e. 3 females against 17 males, and two out of the three female participants fell into the intender group).

# 4. ANALYSIS OF QUESTIONNAIRE DATA

## 4.1 Introduction

In both the laboratory and real-road drives in the EVSC project, participants were considerably more hostile to mandatory ISA than to voluntary ISA. This hostility was somewhat reduced after driving with the system, but was by no means eliminated (Comte, 1999).

It is unlikely that Mandatory ISA could be introduced without general public support. Currently, opinion regarding such a system is not particularly favourable. According to the 1998 Lex survey of British motorists, 27 percent of the driving public would find automatic adjustment of speed to the prevailing limit to be very useful, as compared to 54 percent finding systems warning of congestion or bad weather to be very useful (Lex, 1998). In the 1997 survey, 17 percent of the responding drivers supported the installation of speed limiters on cars. This number compares with 24 percent supporting more speed bumps and 55 percent supporting the wider use of speed cameras (Lex, 1997).

However, it should not be forgotten that, prior to the introduction of legislation for the compulsory wearing of seatbelts in front seats, there was considerable opposition to the measure. Public opinion was only won over during the consequent media debate. Traffic calming has gone through a similar change: when first introduced it was widely opposed by local residents; now it is demanded by residents and tolerated by drivers.

There are also more theoretical grounds for believing that behavioural measures may be able to change attitudes. Spanish research on drink-driving, applying the Theory of Reasoned Action (Fishbein and Ajzen, 1975), has shown that beliefs about the consequences of driving under the influence of alcohol become more favourable with the frequency of driving under the influence in the previous six months. Similarly, drinking intensity was shown to make attitudes towards driving under the influence more favourable (Tejero Gimeno et al., 1997). From this one can conclude that *habituated behaviour* influences *attitudes* rather than the other way round, i.e. people construct a set of attitudes to justify their normal behaviour.

From this, it is possible to hypothesise that, with long-term exposure to ISA; driver attitudes will become more favourable. If confirmed, this could be a very important pointer to changes in public attitudes with increasing exposure to voluntary ISA. It could also be an important contribution to the continuing debate of how best to reduce driver propensity to commit violations on the road.

The Theory of Planned Behaviour (TPB: Ajzen 1985, 1988, 1991) was therefore used as a model for evaluating changes in attitudes to speeding and ISA as result of using the system for an extended period of time.

The TPB provides a parsimonious, deliberative processing model (Conner and Sparks, 1996) which advocates that intentions and perceived behavioural control (PBC) are the proximal determinants of behaviour. Intentions reflect the cognitive representation of an individual's readiness to perform a given behaviour (Ajzen, 1991). PBC describes the individual's perception of the ease or difficulty of performing any given behaviour (Ajzen, 1991).

As intentions and PBC are held to be direct antecedents of behaviour, the model also states that intentions are influenced by three additional factors. Attitudes, subjective norms and PBC are direct determinants of intentions:

- Attitudes towards a behaviour reflect the degree of positive or negative evaluation the individual has towards performing the behaviour.
- Subjective norms refer to the perceived social pressure to engage or not engage in a behaviour. These are understood to be the sum of normative beliefs concerning what salient referents believe about the individual enacting the behaviour, weighted by the individual's motivation to comply with this group, summed across the salient referents.
- PBC again reflects the perceived ease or difficulty of undertaking a given behaviour. An individual's perception of control is assumed to be the product of the individual's evaluation of factors likely to facilitate/inhibit the performance of a behaviour and the frequency of their occurrence. These control beliefs can be both internal and external in their nature. As the relative importance of intentions and PBC in predicting behaviour can differ across behaviours and populations, so too can the importance of attitudes, subjective norms and PBC in the prediction of intentions.

Figure 40 provides a schematic representation of the TPB.

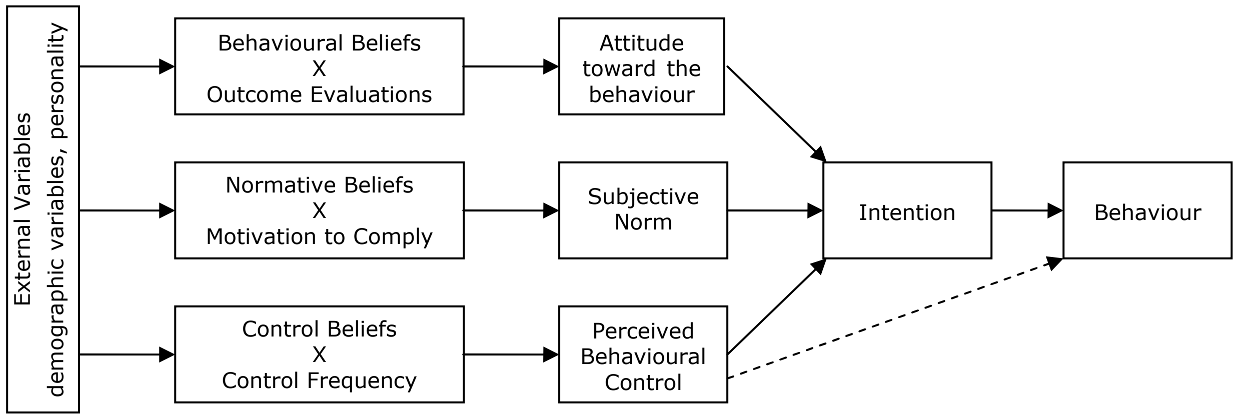



**Figure 40: The Theory of Planned Behaviour (Ajzen, 1988)**

Since the early 1990's research has examined the TPB and drivers propensity to speed (Lawton, Parker, Manstead and Stradling, 1997; Lawton, Parker, Stradling and Manstead, 1997; Parker et al., 1992a; Parker, Manstead, Stradling and Reason, 1992b; Parker, Stradling and Manstead, 1996), dangerously overtake (Parker et al., 1992a; Parker et al., 1992b; Parker, Manstead and Stradling, 1995), drink and drive (Parker et al., 1992a; Parker et al., 1992b), follow closely (Parker et al., 1992a; Parker et al., 1992b), recklessly weave (Parker et al., 1995), recklessly cut in (Parker et al., 1995), run red traffic lights (Manstead, Parker, Stradling and Lawton, 1996), flash at vehicles in front (Manstead et al., 1996) and engage in retaliatory/initiatory violations (Parker, Lajunen and Stradling, 1998).

Research within the driver behaviour domain has also sought to extend the TPB model, including variables such as past behaviour, moral norm and anticipated regret. Several authors have noted the impact of past behaviour upon subsequent behaviour. In a review of 12 intention related studies and five behaviour related studies, Conner and Armitage (1998) concluded that on average, past behaviour explained a further 7.2% and 13% of the variance in intentions and behaviour, respectively. Within the driver domain, habit has been reported as a strong predictor of intention to speed and reported speeding behaviour (Manstead and Parker, 1996). Elliot, Armitage and Baughan (2002) argue that habit may act as a moderator between TPB variables and behaviour, suggesting that drivers with a weak habit to comply with the speed limit base their intentions on attitudes, subjective norms and PBC to a greater extent than drivers with a strong habit to comply. Those such as Beck and Ajzen (1991) and Randall and Gibson (1991) advocate the inclusion of moral norm within the TPB model. Moral norm refers an individual's internalised moral rules or feelings of responsibility. The inclusion of anticipated regret (anticipated affective reaction to the behaviour; see van der Plight and de Vries, 1998b) has also received strong support. Parker et al. (1995) demonstrated that the addition of these personal norm measures improved the prediction of intention to cut in, recklessly weave and recklessly overtake by between 10.1% and 15.3%. Both moral norm and anticipated regret are believed to be especially relevant, since committing driving violations is a socially undesirable behaviour that may evoke anticipatory feelings of negative or indeed positive affect. Risk perception refers to an individual's evaluation of the risk involved in performing a given behaviour. An individual's perception of their societal role (i.e. their self-identity) has also been found to be independently predictive of individual intentions (see Conner and Armitage's review, 1998). To the best of our knowledge, the role of self-identity has not been assessed within driver behaviour research.

Speeding, unsurprisingly, has been the focus of several TPB studies. Parker et al. (1992a) concluded that the performance of the TPB was reasonable, explaining 49.1% of the variance in intention to speed. PBC was identified as the single most important predictor of intentions to speed. Drivers, particularly young males, demonstrated a lesser ability to refrain from speeding, reporting significantly weaker intentions and control over not committing the violation and perceiving significant others to have weaker negative expectations compared to their counterparts (Parker et al., 1992b). Speeding appears to be a social behaviour in which risks are based upon the individuals' perceptions of control and expectations of others and rather less on personal attitudes. Intentions to speed are held to be a function of the driver's assessment of the "reasonableness of a speed limit in a particular context" (Lawton et al., 1997, p. 162). The driver deliberately takes risks.

Primarily the TPB will used as a model to monitor changes in drivers' propensity to exceed the speed limit and disengage the system as a result of experience with ISA. Following the successful completion of all four field trials however, the sample size should also be sufficient to examine the proximal determinants of speeding. Although previous work has explored the theoretical underpinnings of the motivation to speed, conclusions drawn are based upon the prediction of intention to speed. To our knowledge, no previous study has examined the relationship between intention to speed and actual speeding behaviour in an instrumented vehicle. The link between intention and behaviour is certainly well documented (see Armitage and Conner, 2001) for other behaviours but the reliance upon self-report measures within the driver behaviour domain renders their validity subject to the question of social desirability bias. Although speeding has been socially constructed as a 'non-crime' (Corbett, 2000), within the experimental situation drivers may under or over estimate their involvement in speeding violations. The present project will test the predictive utility of the TPB with respect to speeding across three classes of road (motorway, urban, and residential roads) and the addition of measures of moral norm, anticipated regret, past behaviour, risk and self identity will test the sufficiency of the central components of the TPB model.

Analysis based on the first field trial however is limited given the small sample size and will thus concentrate on the change in key TPB constructs following experience of the ISA system.

## 4.2 Analysis on the Theory of Planned Behaviour

As mentioned earlier, completion of the four field trials will allow an evaluation of any changes in attitudes to speeding and ISA as a result of using the system and also test the predictive utility of the TPB. The sample size however is currently too small to attempt the latter. In order to examine changes in the TPB constructs over time and scenarios it would be most appropriate to perform a MANOVA. However given the limited sample this test would prove inappropriate. Comparisons have therefore been made across time on a construct by construct and scenario by scenario basis using a series of repeated measures ANOVAs. Although this test is regarded as more resilient, the sample size and between subject factors included (sex, age group, intention group) compromise the results and make it difficult to draw any strong conclusions. Indeed any significant interactions have been suppressed and ignored since little meaning can be attributed to these. Constraints here also mean that it has been impossible to include other personality measures such as sensation seeking and conscientiousness. As the sample size increases from the subsequent trials the analysis will become more sophisticated and robust.

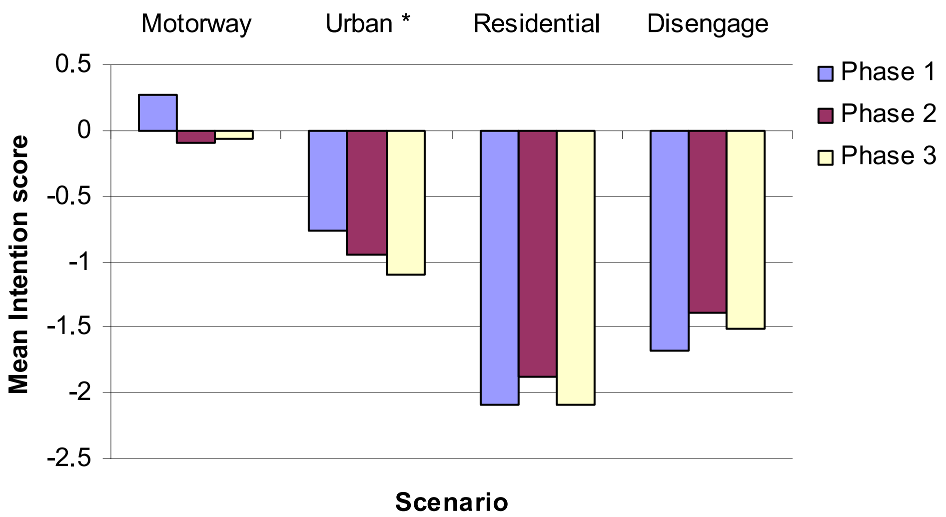



**Figure 41: Mean intention scores by scenario**

Figure 41 highlights the change in intentions over time for each scenario. The TPB proposes that intentions predict behaviour. There were no significant differences in intention scores over time for the motorway, residential or disengage scenario. Intentions to exceed the speed limit on an urban road significantly decreased over time. Post hoc analysis however did not reveal any significant differences between time points. Although there is little effect of the ISA intervention several slight trends can be seen. Over time participants tended to express weaker intentions to exceed the speed limit on a motorway and urban road. Participants' intentions to exceed the speed limit were weakest for the residential road scenario where pedestrians and potential hazards are at their greatest. When ISA was available, intentions to exceed the speed limit decreased except for the residential scenario where intentions slightly increased. Results here may suggest that when restricted to 30mph participants found the speed limit on residential roads inappropriate and as such their intentions and desire to speed increased. When the control of ISA was removed participants' intentions to exceed the speed limit on urban and residential roads weakened. With respect to the system scenario, intentions to disengage the ISA system were relatively low during Phase 1 when participants had no experience of the system. During Phase 2 and 3 intentions to disengage the system increased. It is uncertain why intentions may have increased as this could be due to frustration with the system or simply a response to the inaccuracies in the speed limit map database which meant that participants overrode the system when false speed limits were displayed. Nevertheless, differences here were minimal and intention scores remained negative over time suggesting that the desire to override the system was weak.

Participants held negative attitudes towards exceeding the limit on urban and residential roads. (see Figure 42). Attitudes towards exceeding the speed limit on a motorway and disengaging the system were slightly positive. This may reflect participants' disagreement with the legal speed limit for motorways and suggest speeding is deemed most acceptable on this road category. Attitudes became less favourable towards speeding in only the urban scenario following experience with the ISA system. Differences in scores over time for all scenarios however were insignificant. Again there was little effect of the ISA intervention. Differences across means are extremely small and little meaning should be attributed to these.

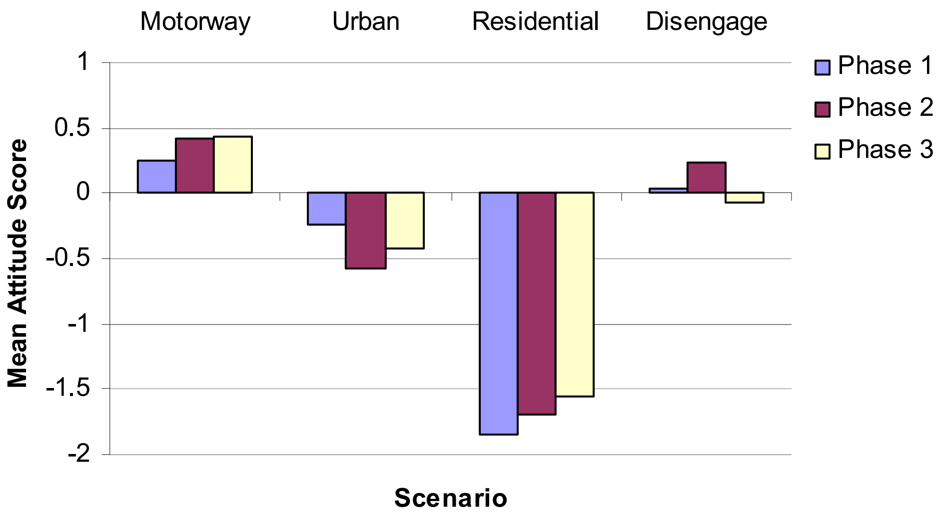



**Figure 42: Mean attitude score by scenario**

Behavioural belief scores provided an indirect measure of participants' attitudes towards exceeding the speed limit and disengaging the system. Repeated measures ANOVAs did not reveal any significant differences over time for the motorway, urban, residential or disengage scenario. However it is of more interest to look at the individual behavioural belief scores rather than the composite mean scores in order to gain an overview of the beliefs that may be amenable to safety campaigns. Again however differences over time are minimal and interpretation should be treated with care.

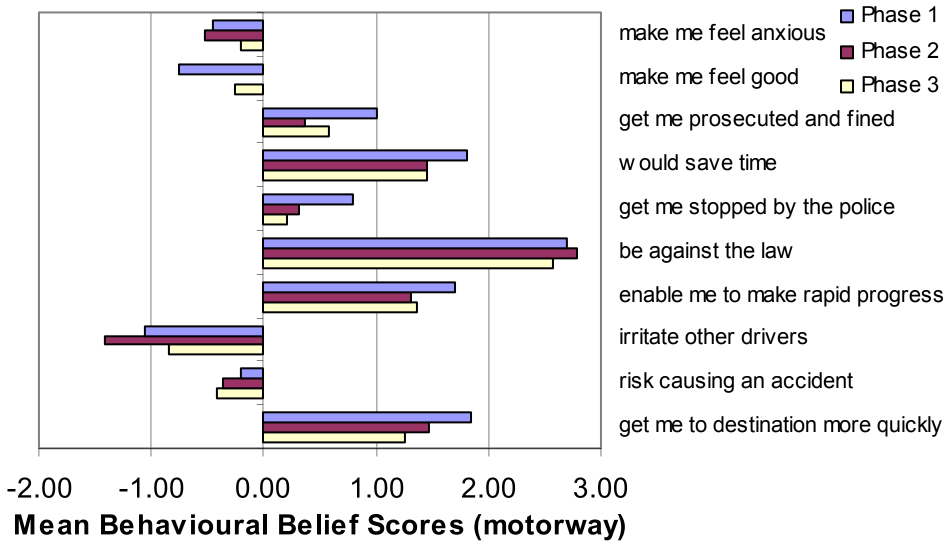



**Figure 43: Mean behavioural belief scores for motorway scenario**

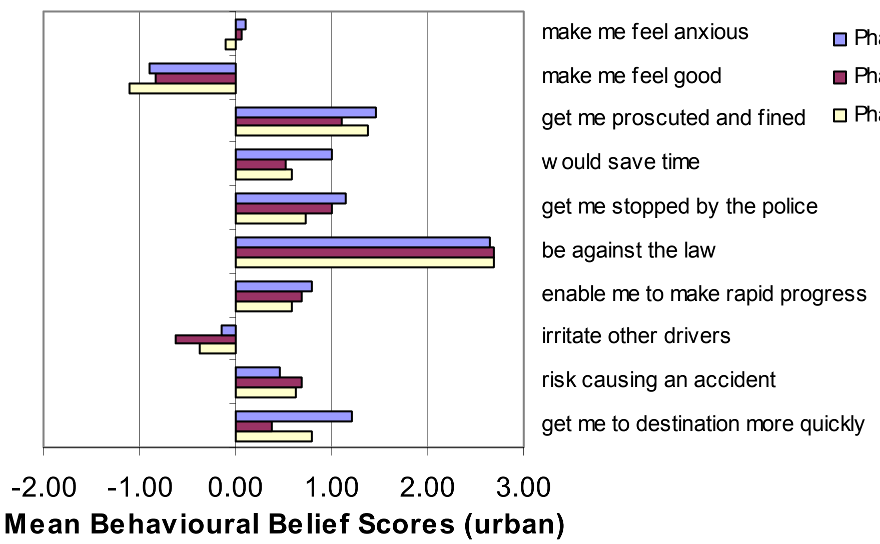



**Figure 44: Mean behavioural belief scores for urban road scenario**

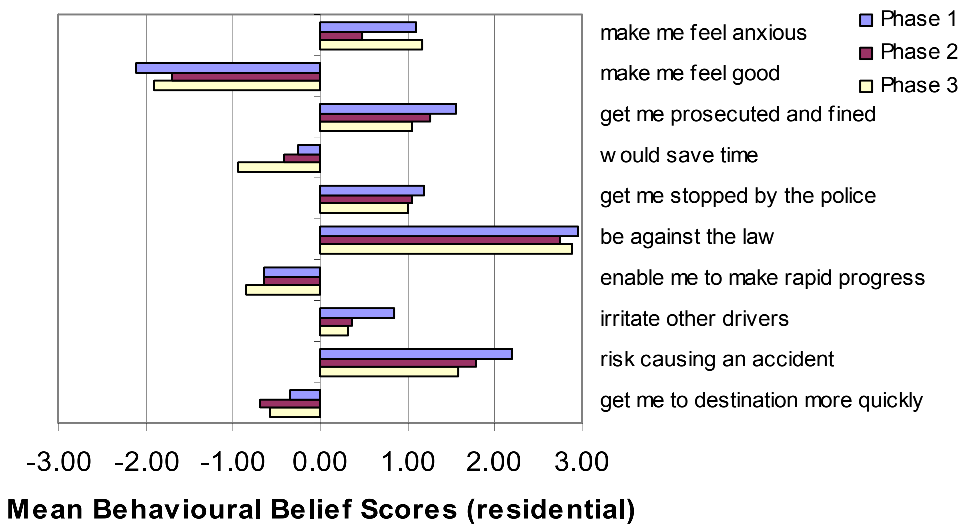



**Figure 45: Mean behavioural belief scores for residential road scenario**

Comparisons across the three speeding scenarios suggest that participants did not believe they would feel anxious speeding on a motorway again suggesting that participants might consider 70mph an inappropriate speed limit for the motorway. During phase two participants were less likely to believe speeding would make them feel anxious. This may be a reflection of a change in the driver's definition of speeding. When initially answering the questions the participants may have defined speeding as x% over the speed limit. However, since the system does not allow them to drive more than 1mph (except when travelling downhill) above the speed limit (and the speedometer reads only 10% above the limit) they may have redefined speeding and consider this much less dangerous. Initially participants strongly disagreed that exceeding the speed limit would make them *feel good*, but, as the freedom to speed was withdrawn, participants' beliefs weakened. Mean scores remained negative, but became less negative over time. Participants appeared to realise that exceeding the speed limit did, in some ways make them feel good. During phase three however, disagreement strengthened to a level similar to that expressed during Phase 1.

Participants' beliefs regarding *being prosecuted and fined* and *stopped by the police* can be considered together. Figure 43, Figure 44 and Figure 45 suggest that following experience of the ISA system participants thought it less likely that speeding would lead to them being prosecuted and being stopped by the police, suggesting the system had 'dampened' participants' perceptions of the legal implications of speeding. This may be participants response to watching other traffic 'getting away with' speeding whilst they were restricted to the speed limit. Participants' beliefs that exceeding the speed limit would *save time*, enable them to *make rapid progress* and *get them to their destination on time* generally tap into participants perception of their journey times. For all scenarios, participants' beliefs weakened following experience with the system. Participants experience with the ISA system educated them that driving above the legal speed limit does not necessarily reduce journey time. Participants tended to believe that speeding in all scenarios would be slightly more likely to be *against the law* following experience with the ISA system. This is somewhat at odds with their beliefs regarding prosecution and getting stopped by the police. Having gained experience of the system participants were less likely to believe that exceeding the speed limit would *irritate other drivers*. Generally participants negative scores suggested that participants did not believe that exceeding the speed limit would irritate other drivers and having experience of the system their beliefs were strengthened. It is highly likely that keeping within the speed limit may have served to irritate other drivers more than exceeding the limit. Overall participants believed that exceeding the speed limit was likely to *risk causing an accident*. However this was not true for the motorway scenario where participants were unlikely to believe exceeding the speed limit would risk causing an accident. For the residential road and motorway scenario, experience of the ISA system weakened this belief. Only in the urban scenario was this belief slightly strengthened. It may be suggested that when a participants' speed was restricted they evaluated the speed limits as inappropriate and thus exceeding these limits was construed as less harmful. This is especially worrying for the residential scenario where hazards are abundant.

Overall comparisons of these behavioural beliefs provide useful societal beliefs that can be encouraged and enhanced to reduce speeding and also negative beliefs that must be tackled and corrected.

Given that the behavioural belief scores for the disengage scenario range only from −1.26 to +1.15, any differences noted are minimal and beliefs are on the whole relatively neutral. The ISA intervention did not influence behavioural belief scores and trends shown below should be interpreted with caution. Figure 46 highlights that participants were unlikely to believe disengaging the system would make them *feel anxious* following prolonged experience with the system. They were however more likely to think that disengaging would make them *feel good* following this prolonged experience. During phase two participants were more likely to believe that disengaging the system would *save time*, evoke *relief* and *reduce pressure from other traffic*. These beliefs tended to weaken during phase three. Participants were also unlikely to believe that disengaging the system would *risk causing an accident* and this belief strengthened over time.

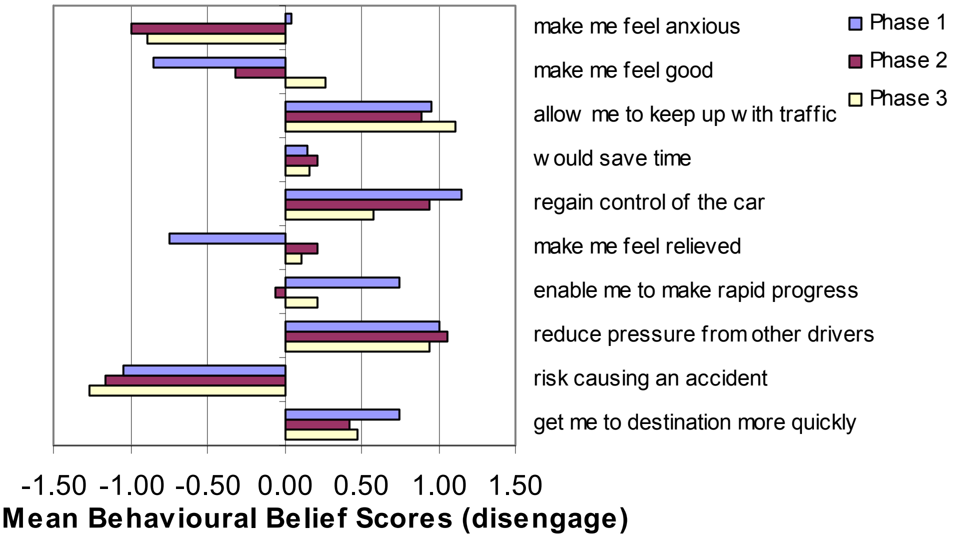



**Figure 46: Mean behavioural belief scores for the disengage scenario**

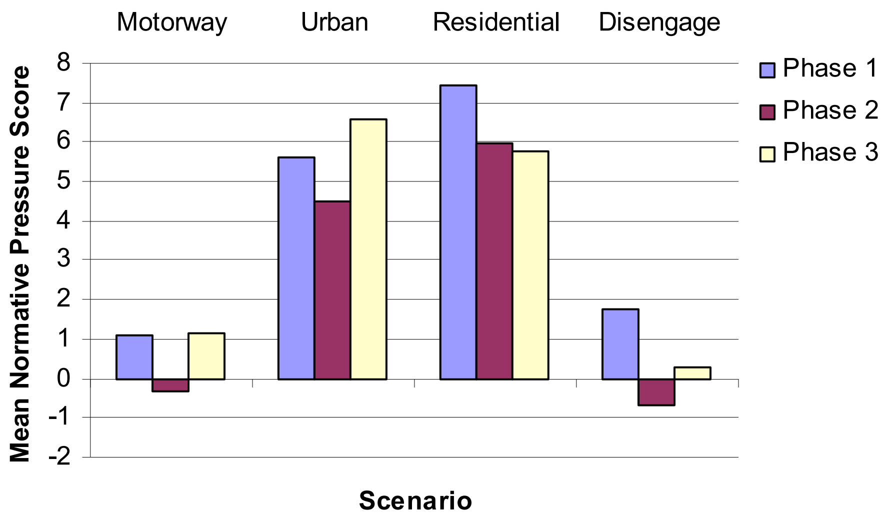



**Figure 47: Mean normative pressure score by scenario**

Perceived pressure from significant others decreased during Phase 2 and increased in Phase 3 for all scenarios (except the residential scenario). Whilst driving under the ISA control, participants felt their significant other were less likely to disapprove of them exceeding the speed limit or disengaging the system. Differences may again be attributable to a shift in participants' definition of speeding. They may have felt that significant others would disapprove of excessive speeding but when limited to the speed limit they may have felt that significant others would not have disapproved of driving a certain percentage above the speed limit. There were no significant differences in normative pressure scores over time for any of the scenarios.

**Table 21: Mean motivation to comply scores over time**

| Referent Group | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|
| Police | 5.60 | 5.00 | 5.37 |
| Other road users | 4.55 | 3.95 | 4.37 |
| Family | 5.15 | 5.11 | 5.16 |
| Friends | 3.60 | 3.79 | 4.05 |
| Spouse/partner | 5.74 | 5.37 | 5.58 |

As can be seen in Table 21**,** the driver's spouse or partner was the most influential referent. It is important that participants begin to believe that their significant others (i.e. the police, other road users, their family, other bikers) would disapprove of them exceeding the speed limit and that it is important to consider their beliefs when they are on the road. Implications for successful campaigns are discussed later.

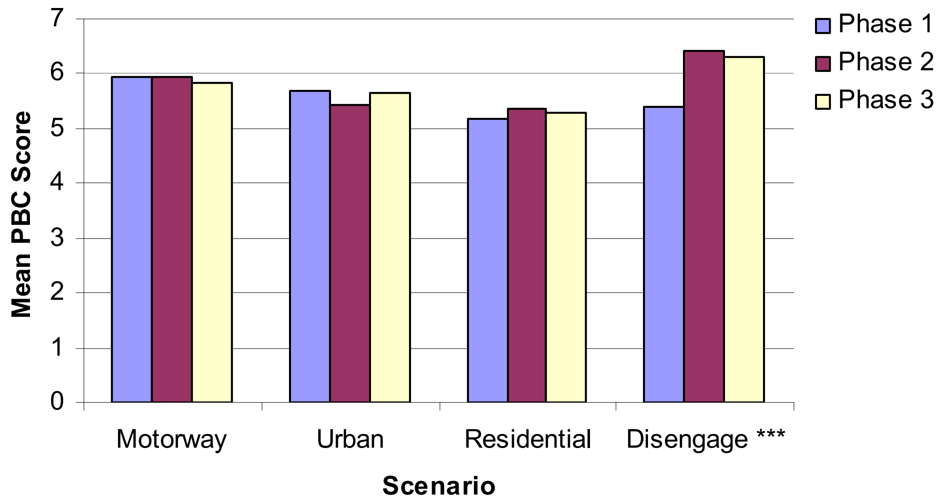



**Figure 48: Mean perceived behavioural control score by scenario**

Figure 48 generally shows little change in participants' perceptions of control during Phase 2 (except for the disengage scenario). This is again slightly surprising, because it was thought that driving with the system would have decreased participants' perceptions of control. There were no significant differences in PBC scores over time for the motorway, urban or residential scenario. A significant difference was across the disengage scenario. Post hoc analysis revealed a significant increase in PBC from Phase 1 to Phase 2; participants felt they were in greater control of their ability to disengage the system.

Figure 49, Figure 50, Figure 51 and Figure 52 provide a comparison of the stated control factors over time and scenarios.

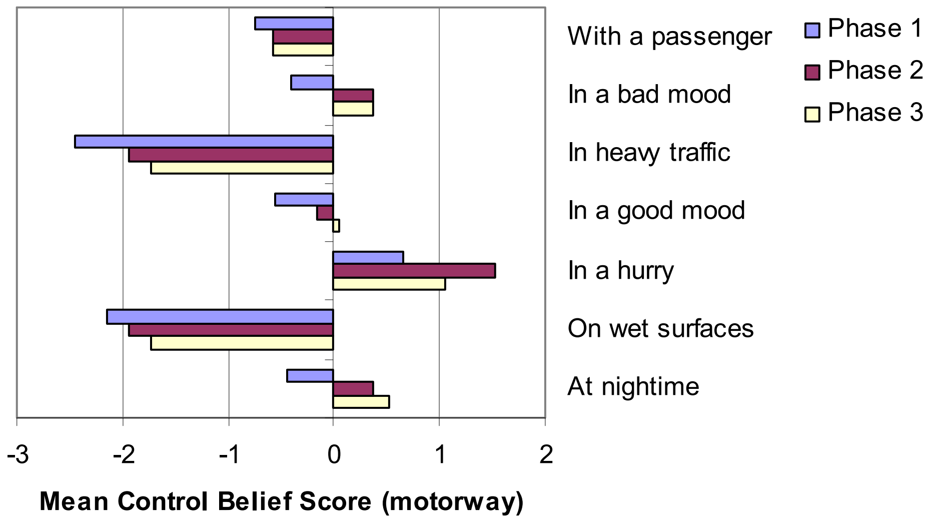



**Figure 49: Mean control belief scores for motorway scenario**

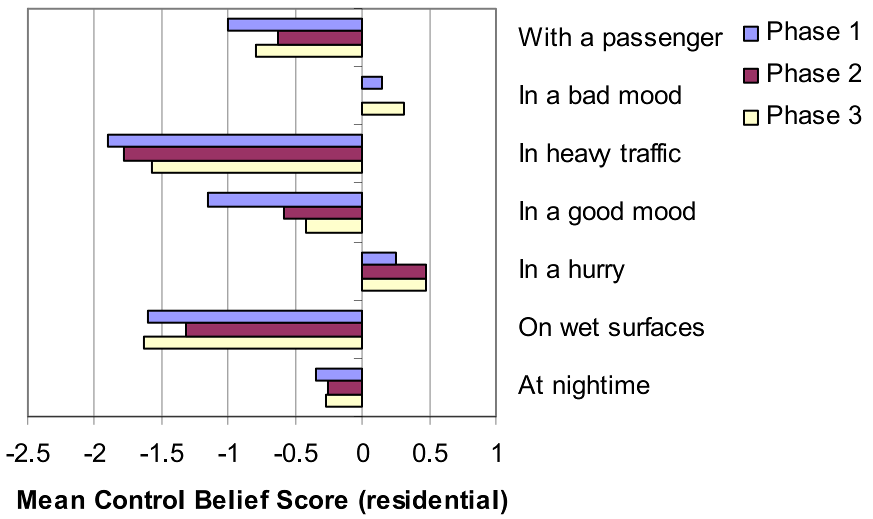



**Figure 50: Mean control belief scores for urban scenario**

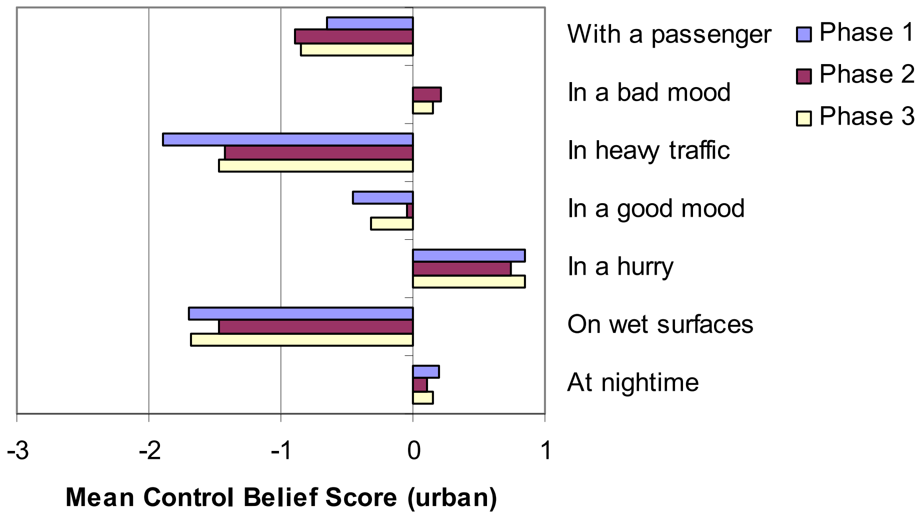



**Figure 51: Mean control belief scores of residential scenario**

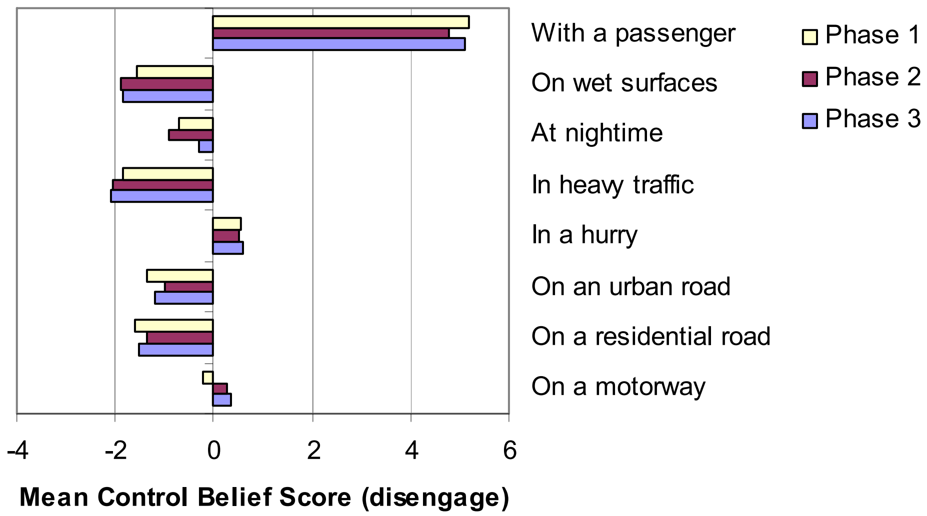



**Figure 52: Mean control belief scores for disengage scenario**

As can be seen the majority of control factors were generally seen as inhibiting participants' propensity to speed and disengage the system, except for *being in a hurry* and in a bad mood, where this was seen to facilitate speeding. Participants felt they were more likely to speed when they were in a hurry. They were also more likely to disengage the system when they were in a hurry or with a passenger. Across all scenarios, the majority of control factors were regarded as less inhibiting during Phase 2 when compared to Phase 1 and even less inhibiting in Phase 3. During Phase 1 participants felt that residential and urban roads were the most inhibiting roads. They were less likely to disengage the system on these roads than any other road type. However, as can be seen in Figure 52, experience with the ISA system slightly weakened this effect. Driving on a motorway was shown to facilitate participant's propensity to disengage the system. Participants may have disengaged the system to overtake, keep up with the fast moving traffic or simply because this road type affords the greatest opportunity to speed.

Generally the relatively high scores suggest that participants believed that exceeding the speed limit across all scenarios and disengaging the system was morally wrong (see Figure 53). As has been shown already, speeding on motorways seems the most accepted. Moral norm scores during Phase 2 tended to decrease for all scenarios. Indeed, although there were no significant differences in moral norm scores over time for the motorway, and residential scenario, there was a significant difference in scores over time for the disengage scenario. Post hoc analysis did not reveal any significant difference between phases; however the means suggest a significant difference in moral opinion before and after experience with the system. Participants significantly weakened their belief that disengaging the system was morally wrong following prolonged exposure to the system. Changes here may reflect participants need to disengage the system when false speed limits were presented.

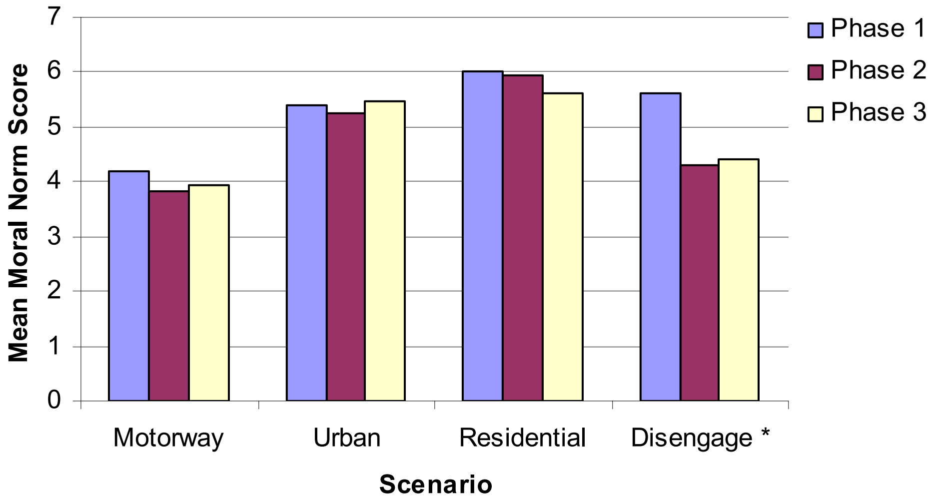



**Figure 53: Mean moral norm score by scenario**

Although participants tended to believe that exceeding the speed limit was morally wrong, they did not tend to anticipate regretting engaging in this behaviour (see Figure 54). Again participants reported anticipating least regret for exceeding the speed limit on a motorway. There were no significant differences across all scenarios and during Phase 2 participants' ratings tended to decrease rather than increase.

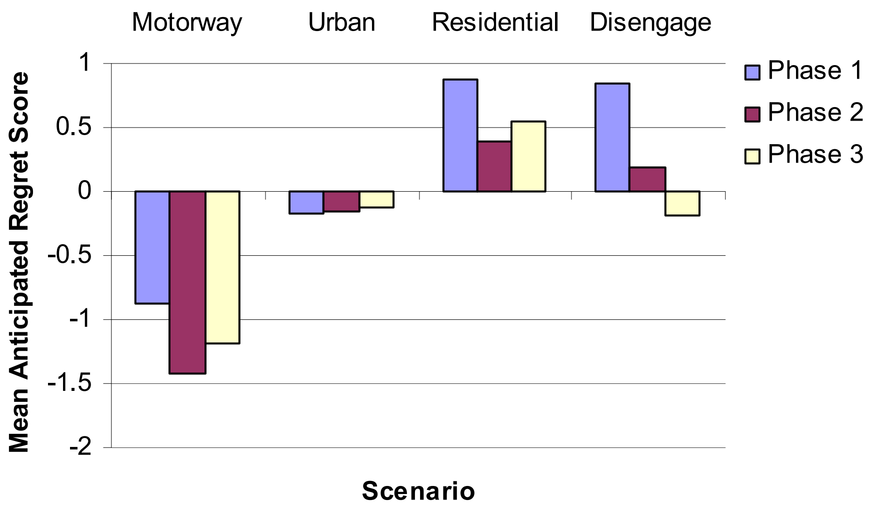



**Figure 54: Mean anticipated regret score by scenario**

Given the controlling nature of the system, past behaviour scores (see Figure 55) are as expected. Driver's self-reported propensity to exceed the speed in the last month decreased during Phase 2. For the urban and residential scenarios, self-reported speeding in Phase 3 increased but was still lower than that reported at Phase 1, suggesting that the effects of ISA may have been sustained throughout unsupported driving. For the motorway scenario, self-reported speeding increased during Phase 3. There were no significant differences in past behaviour scores over time for the motorway or residential scenario. However, there was a significant difference in past behaviour scores over time for the urban scenario. Post hoc analysis however did not reveal any significant differences between Phases.

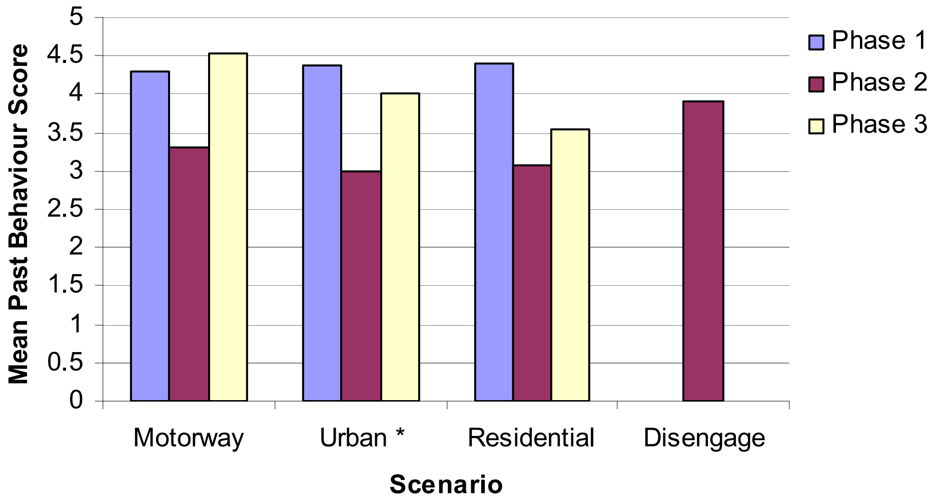



**Figure 55: Mean past behaviour score by scenario**

Comparisons of past behaviours can not be made with respect to disengaging the system since participants had no prior experience of this technology. However it can be seen from Figure 55 that participants had disengaged the system quite frequently in the past.

Figure 56 suggests that participants' perception of the risk involved in speeding on a motorway and residential road significantly decreased during Phase 2. Post hoc analysis revealed a significant difference between Phase 1 and Phase 2 for the residential scenario. No differences were identified for the motorway scenario. Experience of the system weakened participants' perception of risk. This may again be attributable to a change in participants' perceptions of speeding. Since the system defines speeding as anything above the speed limit, participants may have considered this much less risky than what they had previously considered speeding.

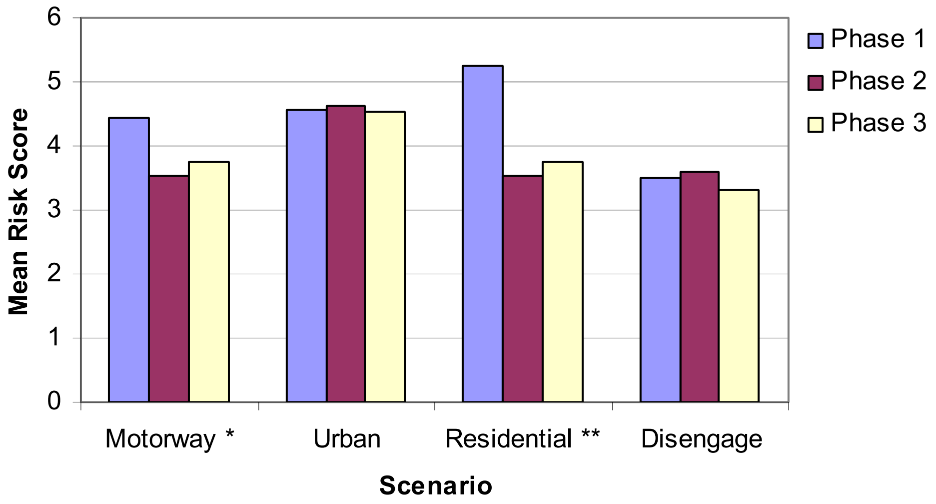



**Figure 56: Mean risk score by scenario**

Self identity measures were taken during each phase. As can be seen in Table 22, when driving under the ISA system participants were slightly less likely to identify themselves as a safe driver. However this difference is minimal and there was no significant difference in scores over time.

**Table 22: Mean self-identity scores over time**

| Phase | Mean Score |
|---|---|
| Phase 1 | 6.10 |
| Phase 2 | 5.74 |
| Phase 3 | 5.94 |

**Table 23: Correlation between TPB constructs and behavioural intention scores across time and scenarios**

Note 1: * denotes significance at the 0.05 level, ** denotes significance at the 0.01 level, *** denotes significance at the 0.001 level

| Construct | Phase 1 Correlations with Intentions | | | | Phase 2 Correlations with Intentions | | | | Phase 3 Correlations with Intentions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | motorway | urban | residential | disengage | motorway | urban | residential | disengage | motorway | urban | residential | disengage |
| ATT | 0.822*** | 0.873*** | 0.604** | 0.111 | 0.442 | 0.560* | 0.733*** | 0.443 | 0.553* | 0.660** | 0.586** | 0.111 |
| BE | 0.744*** | 0.674*** | 0.342 | 0.263 | 0.702*** | 0.496* | 0.564* | 0.587** | 0.567* | 0.249 | 0.377 | 0.263 |
| NBMC | -0.630** | -0.722*** | -0.509* | -0.602** | -0.600** | -0.321 | -0.441 | -0.209 | -0.583** | -0.478* | -0.450 | -0.602** |
| PBC | 0.520* | 0.365 | 0.163 | 0.327 | 0.335 | 0.144 | -0.433 | 0.108 | 0.420 | -0.002 | -0.184 | .327 |
| CBF | 0.555* | 0.555* | 0.449* | 0.163 | 0.392 | 0.437 | 0.215 | 0.662** | 0.346 | 0.404 | 0.302 | 0.163 |
| MN | -0.598** | -0.560** | -0.440 | -0.272 | -0.559* | -0.390 | -0.361 | -0.274 | -0.731*** | -0.477* | -0.486* | -0.272 |
| AR | -0.646** | -0.671*** | -0.184 | 0.050 | -0.573* | -0.438 | -0.221 | -0.523* | -0.471* | -0.049 | -0.449 | 0.050 |
| PB | 0.669*** | 0.803*** | 0.601** | - | 0.290 | 0.102 | 0.374 | 0.653** | 0.746*** | 0.671** | 0.520* | - |
| RISK | -0.530* | -0.523* | -0.545* | -0.364 | -0.530* | -0.519* | -0.392 | -0.137 | -0.628** | -0.491* | -0.460* | -0.364 |
| SI | -0.230 | -.0289 | -0.521* | -0.471* | -0.194 | -0.251 | -0.489* | 0.201 | -0.222 | -0.585* | -0.353 | -0.471* |

Table 23 provides a comparison of the TPB constructs significantly correlating with behavioural intentions over time and scenarios. There appeared to be little change in the significant correlates over time.

Generally, comparisons across scenarios suggest that that those who intended to speed during Phase 1 tended:

- to possess more favourable attitudes towards exceeding the speed limit
- to believe that more positive than negative outcomes would result from exceeding the speed limit (except for residential roads)
- to perceive less normative pressure from significant others
- perceive greater control over exceeding the speed limit (except for residential and urban roads)
- to believe that the stated control factors were more likely to facilitate rather than inhibit their exceeding the speed limit
- not to believe that exceeding the speed limit was morally wrong (except for residential roads – although this was approaching significance)
- not anticipate regretting exceeding the speed limit (except for residential roads)
- to have exceeded the speed limit frequently in the past
- to perceive less risk in exceeding the speed limit
- to have a weaker self identity as a safe driver (except for motorway and urban roads)

Generally, comparisons across scenarios suggest that participants intending to exceed the speed limit during Phase 2 tended:

- to possess more favourable attitudes towards exceeding the speed limit (except for motorways – although this was approaching significance)
- to believe that more positive than negative outcomes would result from exceeding the speed limit
- to perceive less normative pressure from significant others (except for urban and residential roads – although this was approaching significance for the residential roads)
- to not to believe that exceeding the speed limit was morally wrong (except for residential and urban roads)
- not anticipate regretting exceeding the speed limit (except for residential and urban roads –although this was approaching significance for urban roads)
- to perceive less risk in exceeding the speed limit (except for residential roads)
- to have a weaker self identity as a safe driver (except for motorways and urban roads)

Generally, comparisons across scenarios suggest that participants intending to exceed the speed limit during Phase 3 tended:

- to possess more favourable attitudes towards exceeding the speed limit
- to believe that more positive than negative outcomes would result from exceeding the speed limit (except for urban and residential roads)
- to perceive less normative pressure from significant others (except for residential roads)
- not to believe that exceeding the speed limit was morally wrong
- not anticipate regretting exceeding the speed limit (except for urban and residential roads- although this was approaching significance for residential roads)
- to have exceeded the speed limit frequently in the past
- to perceive less risk in exceeding the speed limit
- to have a weaker self identity as a safe driver (except for motorway and residential roads)

Comparisons over time for the disengage scenario revealed an inconsistent pattern.

The TPB was most successful for predicting behavioural intentions to exceed the speed limit on the motorway. This is perhaps because this road types affords the greatest opportunity to speed. Given participants admittance to speed most frequently on this road and feel little regret or moral opposition to this, responses may have been more honest and thus more successful in predicting intentions.

The power of the individual constructs varies slightly over time. During Phase1 Attitudes and past behaviour provide the strongest and most consistent correlates with intentions to speed. Past behaviour did prove a significant predictor of intentions during Phase 2. Given that the ISA system reduced participants ability to speed it is not surprising that this variable becomes an unsuccessful predictor of behaviour. During Phase 3 both attitudes and past behaviour provide the strongest correlates with intentions. The constant power of attitudes across time and scenarios highlights their importance in any targeted safety campaign.

### 4.2.1 Overview of the impact of ISA on the TPB constructs

On the whole results here should be treated with caution. Trends noted are based on very small differences in means and show little effect of the ISA system.

Participants expressed little intention to exceed the speed limit except when driving on motorways. Generally for speeding scenarios participants' intentions weakened during Phase 2 and 3. Only in the residential scenario did intentions strengthen during Phase 2. Intentions to speed on residential roads still remained negative over time however. Frustration at the 30mph speed limit was suggested as a potential explanation for this trend. Comparisons of mean trends for the speeding scenario provide encouraging results that the physical enforcement of speed may be sufficient to change participants' intentions. However no significant differences were found and thus conclusions are only tentative. For the disengage scenario participants intentions strengthened but still remained negative. Inaccuracies in the speed limit database were discussed as a potential reason for this increase.

Attitudes correlated positively with intentions such that those participants with more favourable attitudes towards speeding were more likely to intend to exceed the speed limit. Attitudes did not prove to be a significant predictor of participants' intentions to disengage the system. There was little effect of the ISA system on participants' attitudes towards speeding. Attitudes towards exceeding the speed limit on a motorway were slightly positive and became more favourable with experience. Participants held negative attitudes towards exceeding the speed limit on residential and urban roads but these became less favourable following experience with ISA for the urban scenario only. Although attitudes towards disengaging the system became more favourable, problems with the mapping software were discussed as possible explanations.

Behavioural beliefs correlated positively with intentions such that those who believed more positive outcomes would result from speeding or disengaging the system were more likely to intend to do such. Differences in behavioural beliefs over time are again minimal, but the direction of change in mean scores does hint at some possible target beliefs for intervention. Examination of the changes in behavioural beliefs identified several negative beliefs regarding speeding to be tackled. Compared with Phase 1, experience with the ISA system led participants to believe that exceeding the speed limit was less likely to make them feel anxious, more likely to make them feel good, less likely to lead to them being prosecuted and fined, stopped by the police less likely to irritate other drivers and less likely to lead to an accident. Several positive changes were also noted however. Following experience with the system, participants were more likely to believe that exceeding the speed limit would be against the law and less likely to believe that speeding would save time, allow them to make rapid progress and get them to their destination on time. These results are encouraging in that the system weakened those beliefs regarding journey time. Loss of time is a very influential factor in today's society and use of the system has challenged and disproved critics concerns regarding increased journey time. In order to tackle the increase in negative beliefs, campaigns running during implementation should emphasise the negative emotive reactions to speeding, the direct link between speed and accidents and the risk of financial loss from fixed penalties. With respect to the disengage scenario, experience with the system led participants to believe that disengaging the system was less likely to make them feel anxious, more likely to make them feel good and relieved and relive pressure from other traffic. Campaigns should again tackle the emotive reactions associated with disengaging the system and comfort drivers, emphasising that the speed they travel at is within their control and not determined by tailgating drivers. Nevertheless experience with the system again challenged a key concern regarding journey time. Participants were less likely to believe that disengaging the system would allow them to keep up with the traffic, enable them to make rapid progress and enable them to get to their destination more quickly.

Subjective norms correlated negatively with intentions such that those who perceived less pressure from significant others not to exceed the speed limit or disengage the system were more likely to intend to do so. Perceived pressure from significant others regarding speeding and disengaging the system was also weakened during Phase 2, suggesting that participants felt it was less likely important others would disapprove of these behaviours. It would therefore seem appropriate to raise drivers' awareness of the impact of speeding on their significant others. In view of the fact that participants' spouses or partners, family and the police were the most influential referents, it is important that campaigns promote the importance of these individuals, their disapproval of speeding and the potential impact of speeding on their lives. Steps should be taken to ensure police presence is directly or indirectly felt. Although direct policing may not always be appropriate, indirect measures such as speed cameras, police warning signs and information leaflets endorsed by the police might prove beneficial additions to any targeted campaign.

PBC was rarely a significant correlate with intentions and changes over time were minimal. A significant decrease in PBC score was expected given the control nature of ISA however this was not the case.

Control factors positively correlated with intentions such that those who believed the stated factors were more likely to facilitate exceeding the speed limit or disengaging the system were more likely to intend to do such. Control factors were generally seen to inhibit participants' propensity to speed. Being in a hurry was deemed to facilitate participants' propensity to speed. This along with the presence of a passenger was also seen to facilitate participants' propensity to disengage the system. Comparisons of the control factors suggests that following experience with the system participants generally view these factors as less inhibiting than before. Campaigns should emphasis that driving with a passenger, in a good or bad mood, in heavy traffic, in a hurry, on wet surfaces and at night-time are not excuses to exceed the speed limit or disengage the system. Indeed the consequences of these factors should be highlighted as important reasons not to do such. Similarly since the presence of a passenger was also seen to facilitate disengaging the system, campaigns should also target passengers and highlight their risks of being involved in an accident.

Moral norms and anticipated regret correlated negatively with intentions such that who did not regard speeding and disengaging the system as morally wrong and those who did not anticipate regretting doing such were more likely to intend to perform these behaviours. For the speeding scenarios the presence of ISA did appear to affect participants' personal norms such that they tended to weaken their belief that speeding was morally wrong. Participants did not anticipate regretting speeding on motorways and urban roads and this belief strengthened for the former following experience with the system. For the disengage scenario moral norm scores significantly dropped over time with experience of the system. Anticipated regret also weakened. Changes in personal norms here may be a reflection of inaccuracies in the speed limit map. Where the system displayed inaccurate and subsequently unsafe speed limits participants are less likely to regret overriding the system as in most cases it is safer to do so.

Past behaviour positively correlated with intentions such that those who had frequently exceeded the speed limit in the past intended to do so in the future. As expected, past measures tended to decrease following experience with the system. This was inevitable given the controlling nature of the system.

Perceptions of risk on the whole were negatively correlated with participants' intentions such that those perceiving less risk associated with speeding and disengaging the system were more likely to intend doing such in the future. Participants' perceptions of the risk involved in exceeding the speed limit and disengaging the system slightly decreased following experience with the system. This was discussed in terms of changes in participants' perceptions of speeding and uncertainty regarding the appropriateness of speed limits. Campaigns should seek to emphasise that exceeding the speed limit by only a small percentage can dramatically increase the risk of being involved in an accident.

Self-identity generally negatively correlated with intentions such that those who did not see themselves as a safe driver were more likely to intend to exceed the speed limit or disengage the system in the future. Experience of the system marginally lowered participants' perception of themselves as a safe driver. It would be of importance, therefore, to highlight the benefits of being a safe driver. Encouraging the formation of such a self identity is clearly a complex process but campaign which emphasised the positive aspects of this identity (e.g. thoughtfulness of others, calm) and countered the negative (e.g. carefree) might increase this self identity.

### *4.2.2 Relationship between TPB and behaviour measures*

Given the limited sample size it is not possible to test the predictive utility of the Theory of Planned Behaviour with respect to speeding. Simple correlations between the TPB constructs and behaviours measures have therefore been calculated. It is important that the behaviour measure selected closely matches that described within the TPB scenarios in the questionnaires. The scenarios relate to exceeding the speed limit on a 70mph motorway, 40mph urban road and 30mph residential road. The percentage of distance spent travelling above the speed limit has therefore been chosen a key measure of behaviour. Given that participants definition of speeding is perhaps not strictly 1mph above the speed limit the threshold for issuing fixed penalties has also been used. The Association of Chief Police Officers (ACPO) issues guidance to police officers and advocates that the issue of fixed penalty notices is likely to be the minimum appropriate enforcement action as soon as the speeds noted in Table 24 have been reached.

**Table 24: Fixed Penalty Guidelines**

| Limit | Fixed Penalty |
|---|---|
| 30 mph | 35 mph |
| 40 mph | 46 mph |
| 70 mph | 79 mph |

When examining the power of the TPB constructs it is important to correlate cognitions measured at one time point with *prospective* behaviour measures. Although it is possible to correlate, for example, cognitions measured at the end of Phase 2 with behaviour recorded during Phase 2, it would be impossible to rule out that the behaviour had not driven the cognitions rather than the reverse. The analysis therefore concentrates on prospective correlations. Cognitions measured at the start of the trial, before having driven the ISA vehicle, have been correlated with behaviour throughout Phase 1, 2 and 3. Cognitions measured at the end of Phase 2 have been correlated with behaviour throughout Phase 3.

Unfortunately the results of correlations highlight very few significant relationships between the TPB constructs and behaviour measures. As can be seen in Table 25, the TPB constructs measured at the start of the trial do not successfully correlate with behaviour measures during Phase 1, Phase 2 or Phase 3 across all road scenarios. Although there are significant correlates (behavioural beliefs and normative pressure) for the residential road scenario during Phase 1, these relationships are in the wrong direction. Only cognitions relating to speeding on a motorway successfully correlate with behaviour during Phase 3. Participants who did not regret speeding on a motorway and had frequently done so in the past were significantly more likely to drive at 70mph or more on motorways. Those who had exceeded motorway speed limit in the past and perceived less risk in doing such were also significantly more likely to drive at 79mph or more on a motorway and thus receive a fixed penalty notice.

Examination of the correlations between cognitions measured following prolonged experience with ISA and behaviour during Phase 3, provide more promising results and perhaps explain the lack of any significant correlations between Phase 1 cognitions and behaviour. Across all scenarios significant relationships are noted (see Table 26). The motorway scenario is most successful. Comparisons of mean scores for TPB variables such as attitudes, moral norm and anticipated regret have suggested that participants hold more favourable attitudes towards speeding on motorways and are least likely to regret speeding on this road type. It may be therefore that participants have been more honest and open about their cognitions relating to speeding on this road type since speeding is generally the norm. Moreover motorways provide the greatest opportunity for speeding. Given that cognitions measured during Phase 2 provide more significant correlates than those reported during Phase 1 it seems that initial cognitions are less valid (predictive) perhaps because they are being unrealistic about how behaviour will change with the new car/new system. Once participants have gained prolonged experience with the vehicle itself then cognitions become more realistic and predictive of behaviour. Since the motorway scenario is the most successful, the correlations perhaps provide most insight into the TPB-Behaviour relationship.

Those who exceed the speed limit on a motorway tend:

- to possess more favourable attitudes towards exceeding the speed limit
- to believe that more positive than negative outcomes would result from exceeding the speed limit
- to believe that the stated control factors were more likely to facilitate rather than inhibit their exceeding the speed limit

- to have exceeded the speed limit frequently in the past
- to perceive less risk in exceeding the speed limit

Cognitions measured during Phase 1 relating to participants intentions to disengage the system were also correlated with the percentage of distance participants drove with ISA disengaged. As can be seen in Table 27 only moral norms significantly correlate with behaviour. Those who are less likely to view disengaging the system as morally wrong are more likely to disengage the system.

**Table 25: Correlations between Phase 1 Cognitions and Speeding Behaviour measured in Phase 1, 2, and 3**

| Constructs | Phase 1 Correlations for Motorway Behaviour | | Phase 2 Correlations for Motorway Behaviour | | Phase 3 Correlations for Motorway Behaviour | |
|---|---|---|---|---|---|---|
| | > 70mph | > fixed penalty (79mph) | > 70mph | > fixed penalty (79mph) | > 70mph | > fixed penalty (79mph) |
| BI | 0.209 | 0.159 | 0.152 | 0.075 | 0.334 | 0.271 |
| ATT | 0.124 | -0.002 | -0.003 | -0.155 | 0.397 | 0.387 |
| BE | 0.187 | 0.233 | 0.169 | 0.087 | 0.366 | 0.378 |
| NBMC | 0.027 | 0.019 | 0.010 | 0.038 | -0.401 | -0.400 |
| PBC | -0.416 | -0.348 | -0.234 | -0.137 | 0.181 | 0.067 |
| CBF | 0.049 | -0.069 | -0.191 | -0.313 | 0.383 | 0.223 |
| MN | -0.074 | -0.167 | -0.062 | -0.081 | -0.270 | -0.363 |
| AR | 0.078 | 0.035 | 0.107 | 0.148 | -0.450* | -0.483 |
| PB | -0.029 | -0.080 | 0.048 | -0.112 | 0.574** | 0.494* |
| RISK | -0.012 | -0.033 | -0.022 | 0.070 | -0.385 | -0.513* |
| SI | 0.053 | 0.041 | 0.247 | 0.302 | -0.185 | -0.064 |
| **Constructs** | **Phase 1 Correlations for Urban Behaviour** | | **Phase 2 Correlations for Urban Behaviour** | | **Phase 3 Correlations for Urban Behaviour** | |
| | > 40 mph | > fixed penalty (46mph) | > 40 mph | > fixed penalty (46mph) | > 40 mph | > fixed penalty(46mph) |
| BI | -0.036 | 0.099 | 0.013 | -0.012 | 0.164 | 0.126 |
| ATT | -0.043 | 0.077 | -0.020 | -0.023 | 0.105 | 0.033 |
| BE | 0.014 | 0.153 | 0.231 | 0.227 | 0.315 | 0.319 |
| NBMC | 0.259 | 0.125 | 0.167 | 0.137 | -0.019 | -0.035 |
| PBC | 0.062 | 0.081 | 0.203 | 0.340 | 0.182 | 0.205 |
| CBF | -0.114 | -0.063 | -0.010 | 0.046 | -0.057 | -0.082 |
| MN | 0.262 | 0.090 | 0.099 | -0.022 | 0.025 | 0.080 |
| AR | 0.219 | 0.122 | 0.134 | 0.047 | -0.058 | 0.020 |
| PB | 0.025 | 0.133 | 0.153 | 0.125 | 0.243 | 0.213 |
| RISK | -0.002 | -0.033 | -0.017 | 0.151 | -0.291 | -0.251 |
| SI | 0.296 | 0.176 | 0.145 | 0.152 | 0.158 | 0.174 |
| **Constructs** | **Phase 1 Correlations for Residential Behaviour** | | **Phase 2 Correlations for Residential Behaviour** | | **Phase 3 Correlations for Residential Behaviour** | |
| | > 30 mph | > fixed penalty (35mph) | > 30 mph | > fixed penalty (35mph) | > 30 mph | > fixed penalty (35mph) |
| BI | 0.052 | -0.075 | 0.120 | -0.099 | -0.014 | -0.117 |
| ATT | -0.292 | -0.329 | -0.062 | -0.304 | -0.035 | -0.170 |
| BE | -0.458* | -0.336 | -0.131 | 0.170 | -0.222 | -0.083 |
| NBMC | 0.409 | 0.446* | 0.149 | 0.008 | 0.065 | 0.172 |
| PBC | -0.324 | -0.224 | -0.279 | 0.146 | -0.179 | 0.023 |
| CBF | -0.262 | -0.277 | -0.232 | -0.011 | -0.235 | -0.203 |
| MN | -0.027 | 0.096 | -0.126 | 0.111 | -0.196 | -0.018 |
| AR | 0.147 | 0.110 | 0.029 | 0.004 | -0.048 | 0.002 |
| PB | -0.183 | -0.134 | 0.105 | 0.084 | -0.076 | -0.070 |
| RISK | -0.435 | -0.357 | -0.592** | -0.318 | -0.356 | -0.329 |
| SI | 0.410 | 0.505* | 0.226 | 0.309 | 0.222 | 0.374 |

**Table 26: Correlations between Phase 2 Cognitions and Speeding Behaviour measured in Phase 3**

| Constructs in Phase 2 | Phase 3 Correlations for Motorway Behaviour | | Phase 3 Correlations for Urban Behaviour | | Phase 3 Correlations for Residential Behaviour | |
|---|---|---|---|---|---|---|
| | > 70 mph | > fixed penalty (79 mph) | > 40 mph | > fixed penalty (46mph) | > 30 mph | > fixed penalty (35mph) |
| BI | 0.461 | 0.264 | 0.198 | 0.088 | 0.143 | -0.029 |
| ATT | 0.682** | 0.542* | 0.240 | 0.205 | 0.248 | 0.136 |
| BE | 0.573* | 0.552* | 0.407 | 0.407 | 0.137 | 0.092 |
| NBMC | -0.364 | -0.271 | 0.144 | 0.190 | 0.350 | 0.434 |
| PBC | 0.458 | 0.440 | 0.201 | 0.269 | -0.283 | -0.115 |
| CBF | 0.607** | 0.361 | 0.073 | 0.039 | 0.069 | 0.073 |
| MN | -0.309 | -0.301 | -0.366 | -0.376 | -0.577* | -0.512* |
| AR | -0.410 | -0.372 | -0.462 | -0.500* | -0.206 | -0.315 |
| PB | 0.494* | 0.610** | 0.593** | 0.687** | 0.609** | 0.557* |
| RISK | -0.598** | -0.553* | -0.382 | -0.342 | -0.347 | -0.193 |
| SI | -0.128 | -0.081 | -0.016 | 0.002 | 0.022 | 0.073 |

**Table 27: Correlation between Phase 1 cognitions and Disengaging Behaviour in Phase 2**

| Construct s in Phase 1 | Phase 2 Correlations for Disengage Behaviour |
|---|---|
| | % opt-out |
| BI | -0.065 |
| ATT | 0.187 |
| BE | -0.088 |
| NBMC | 0.441 |
| PBC | -0.147 |
| CBF | -0.207 |
| MN | -0.471* |
| AR | -0.250 |
| PB | - |
| RISK | -0.140 |
| SI | 0.294 |

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## 4.3 Driver Behaviour Questionnaire

The Driver Behaviour Questionnaire (Parker, Reason, Manstead and Stradling, 1995) measured the frequency with which individuals committed various types of errors and violations when driving, identifying three distinct types of aberrant driving behaviours; errors, lapses and violations. This questionnaire, administered at four time points, provided a self reported measure of changes in driving behaviour over the six month trial period.

Repeated measures ANOVAs were performed to identify significant differences in participants' propensity to engage in aberrant driving behaviours as a result of the four month ISA intervention. Sex, age group and intention group were included as between subject factors.

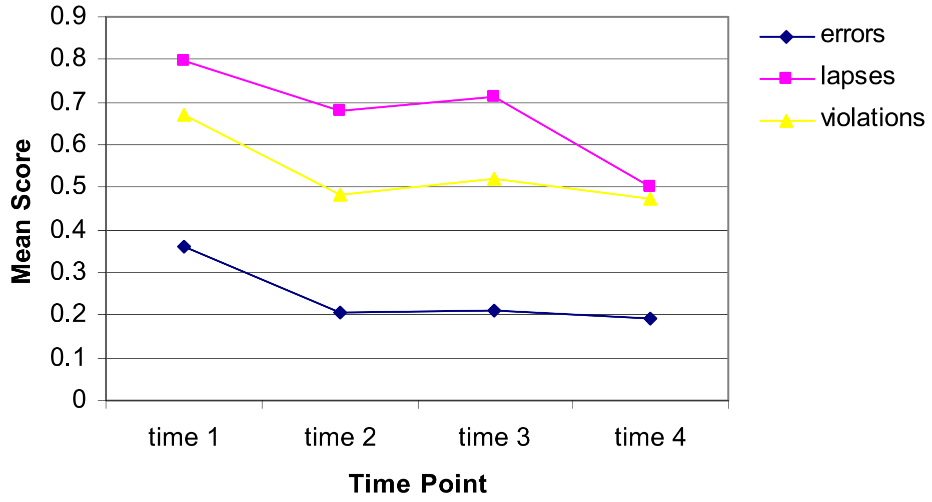


**Figure 57: Mean error, lapse and violation score on DBQ over time**

The analysis revealed significant differences in participants' lapse and error scores over time as a result of the ISA intervention. Figure 57 shows that participants propensity to suffer lapses and errors significantly decreased over time. Post hoc analysis revealed a significant difference in error scores at time 1 and time 2, time 1 and time 3 and time 1 and time 4. Similarly lapse scores at time 4 were significantly lower than at time 1. Prolonged experience with the system significantly decreased participants' propensity to suffer errors and lapses and this was sustained when the ISA system was removed. Participants' propensity to commit violations also appeared to decrease over time. Although there is no significant change over time in violation scores the results were approaching significance ($p = 0.64$) and the small effect size suggests differences over time would be significant with a larger sample size.

## 4.4 Acceptability

Driver acceptance of the ISA system was measured using an acceptability scale of advanced transport telematics developed by Van de Laan, Heino and De Waard (1997). This measure allows system evaluations across the dimensions of usefulness and satisfaction. As can be seen in Figure 58, participants' usefulness and satisfaction ratings increased immediately with experience of the ISA system and continued to increase with prolonged experience.

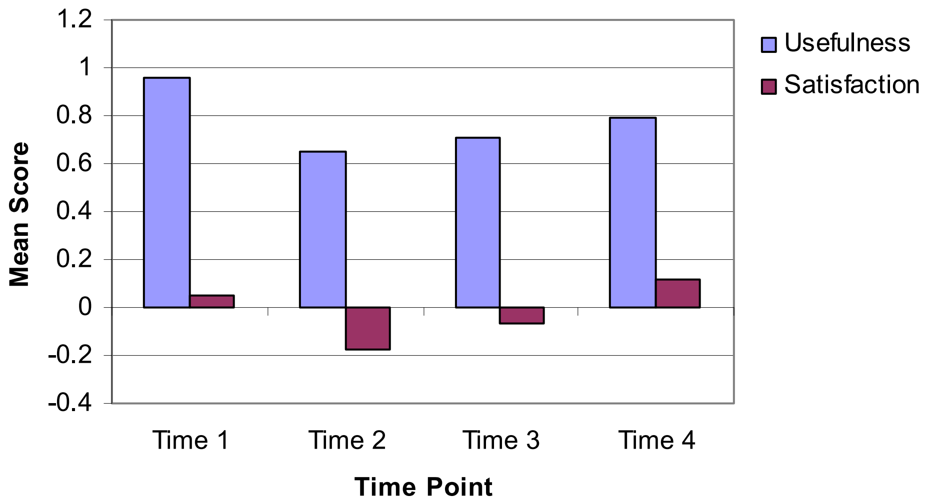


**Figure 58: Acceptability ratings for the dimensions of "usefulness" and "satisfaction"**

A repeated measures ANOVA (with sex, age group and intention group as between subject factors) did not reveal a significant change in usefulness scores over time. Nevertheless Figure 58 does suggest a definite trend such that even though initial experience with the system decreased participants' appreciation of the usefulness of ISA, this increased with prolonged experience and continued to grow when the system is removed.

Similarly a repeated measures ANOVA (with sex, age group and intention group as between subject factors) did not confirmed any significant change in satisfaction scores over time. Again satisfaction with ISA dipped following early exposure to the system but this steadily rose with prolonged exposure, beyond the removal of ISA support.

Prolonged driving experience with the ISA system increased participants' appreciation of the system on the dimensions of usefulness and satisfaction. Interestingly participants rating on both dimensions continued to increase in the final month of driving without ISA. Results may suggest that the return to normal driving amplified the potential of ISA when participants were left without the support of the system. Differences were again non significant however so results should be treated with caution.

## 4.5 System design

Several items sought information regarding the design of the ISA system. Figure 59 and Figure 60 illustrate the most common cues within the system that participants relied upon to inform them of system state changes throughout the 4 month ISA period.

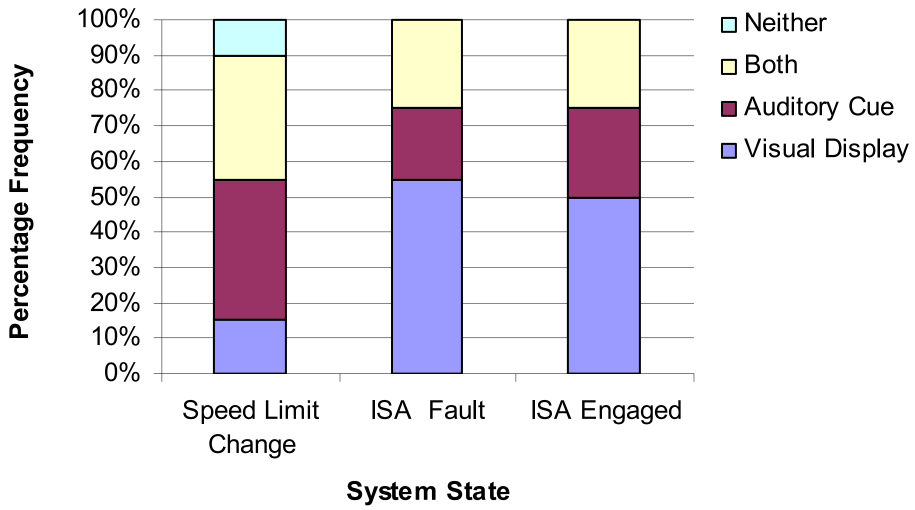


**Figure 59: Most frequent cues relied upon for notification of system state changes during early exposure to ISA**

There are very few differences in the way participants used the ISA system cues as their experience with the system increased. The majority of participants tend to auditory cues to inform them of a speed limit change and a visual cue to identify faults.

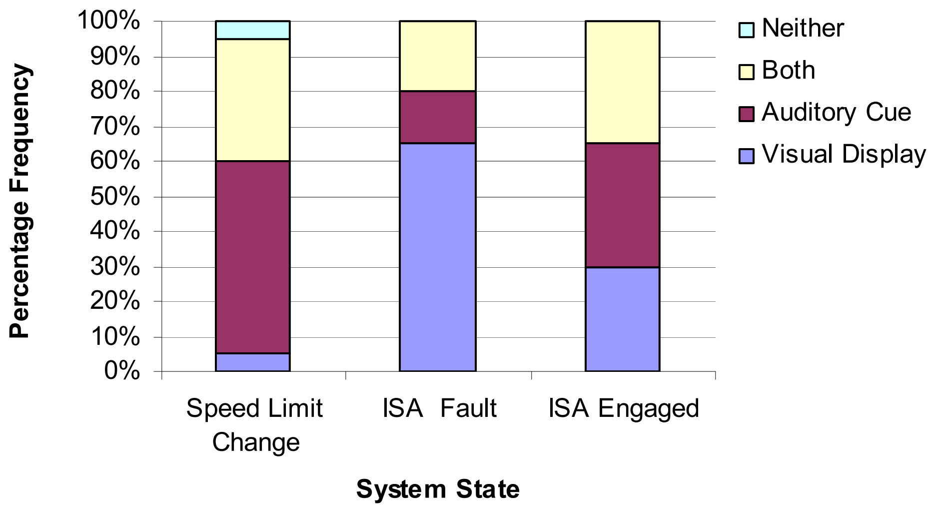


**Figure 60: Most frequent cues relied upon for notification of system state changes following prolonged exposure to ISA**

## 4.6 Driving Experience

Participants were asked several questions relating to their perceptions of driving with ISA compared to driving in a 'normal' vehicle.

### 4.6.1 Risk Perceptions

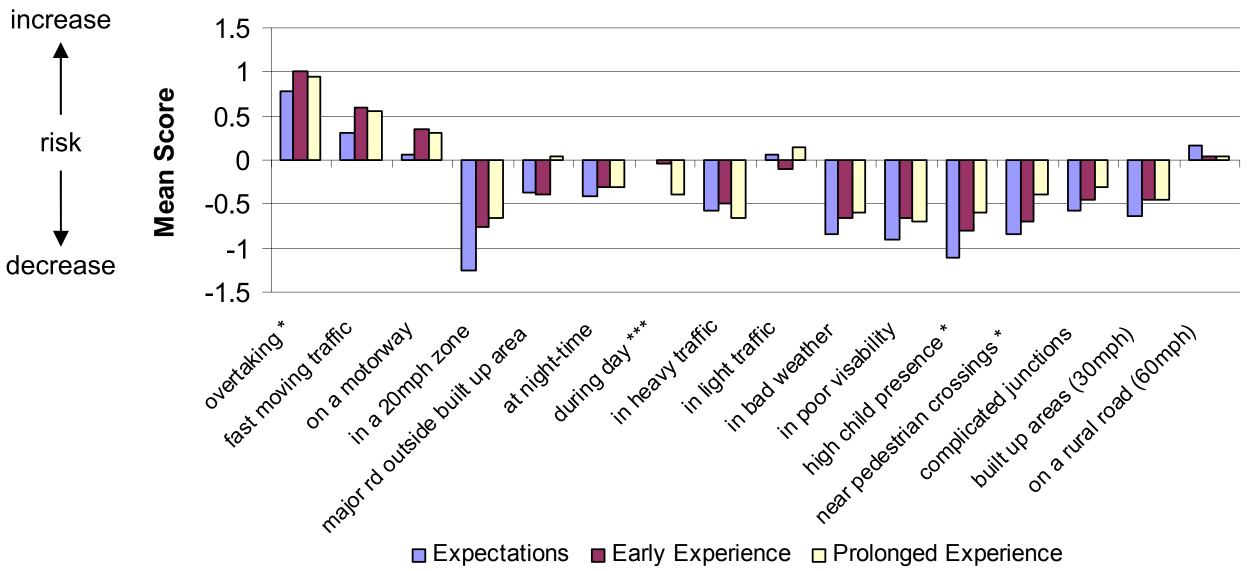


**Figure 61: Perception of change in risk when driving with ISA compared to 'normal' driving**

Figure 61 suggests participants felt at increased risk under ISA control when overtaking and driving on motorways, rural roads and in fast moving traffic compared to normal driving. This increased perceived risk surpassed their expectations and rose with prolonged experience (except for rural roads). Participants appeared to perceive an increase in risk when travelling on roads or in conditions which afforded the opportunity for driving at speed. A repeated measures ANOVA confirmed that participants' perception of the risk involved in overtaking whilst driving with ISA significantly increased. Post hoc analysis revealed a significant increase between participants' expectations of this increased risk and their perceptions of this risk during their early experience. For all other driving conditions, participants tended to feel at less risk when driving with ISA compared to driving in a normal vehicle. Statistical analysis found that whilst participants expected to be at less risk driving during the day with the ISA system, this belief strengthened significantly following experience with the system. Post hoc analysis revealed that participants felt at significantly less risk when driving during the day with prolonged experience of ISA than during their early experience of the system and compared with their expectations of the system. Although participants believed that they were at less risk driving in an ISA car in areas with a high presence of children, this belief significantly weakened with experience of the system. Post hoc analysis did not reveal any differences between time points however. Similarly, whilst participants felt that were at a lesser risk driving near pedestrians crossing in an ISA car, this belief weakened with prolonged experience. Post hoc analysis revealed a significant difference between participants perceived risk expectations and their risk perceptions having gained prolonged experience of the system. Participants perhaps realised that although ISA curtailed their speeds and thus increased their time to react to hazards, it was still their responsibility to remain attentive and take any necessary remedial action. Nevertheless, although the decrease in risk did not tend to meet their expectations, Figure 61 would tend to suggest that participants still considered driving with ISA in the majority of conditions safer than driving in an unsupported car.

### 4.6.2 Frustration

As can be seen in Figure 62, participants expected the ISA system to frustrate others on the road but they did not expect it to frustrate themselves as the driver. When driving with the system however participants did report experiencing frustration, although this reduced with prolonged experience. The difference over time however was non-significant. With prolonged use of the system participants were also less likely to believe that their driving with ISA would prove a source of frustration to other drivers. Again however this trend was non-significant.

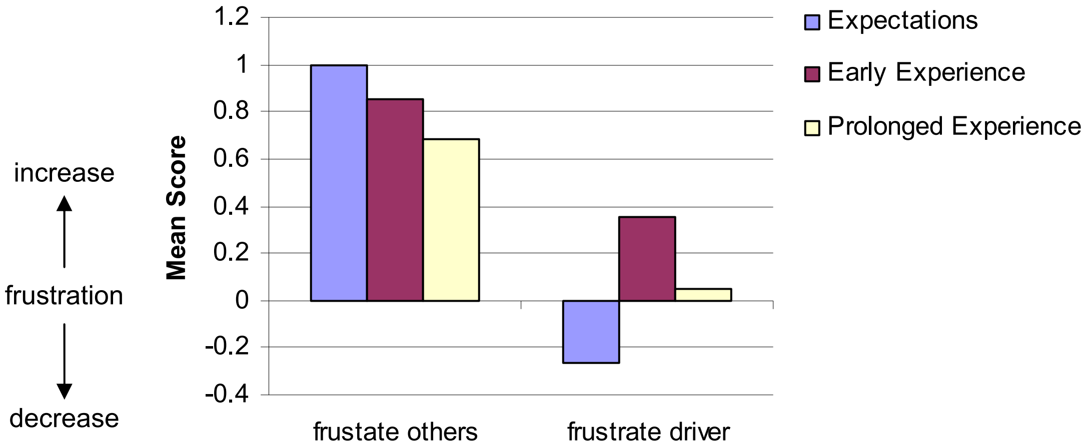


**Figure 62: Influence of ISA on frustration experienced**

Further questioning revealed the specific situations where participants' frustration was increased as a result of the ISA system.

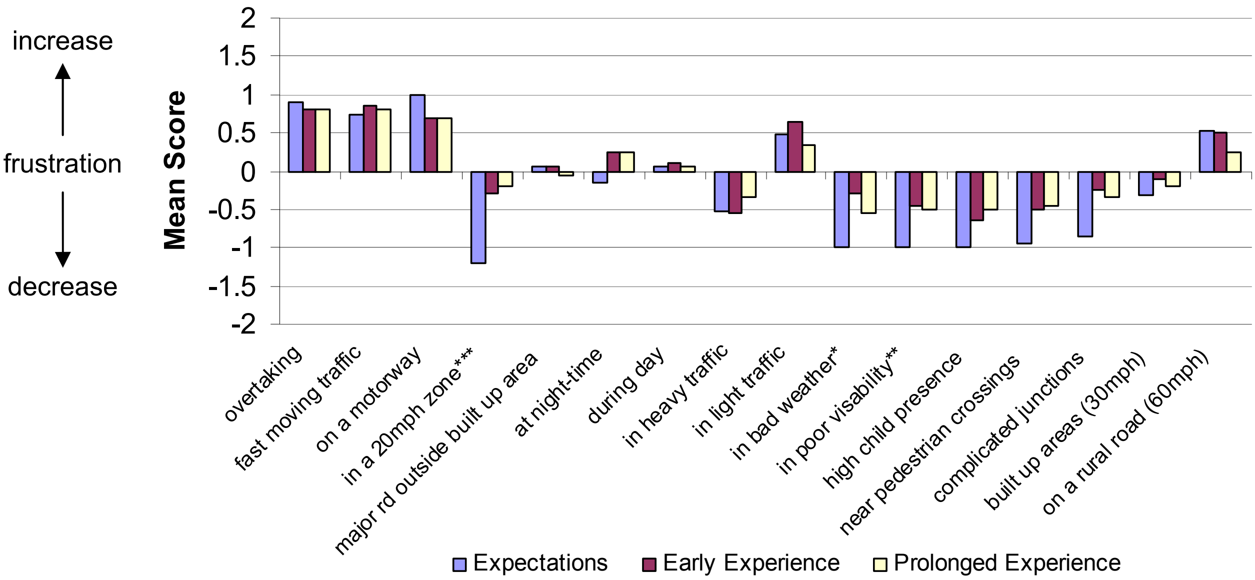


**Figure 63: Perception of change in frustration experienced when driving with ISA compared to 'normal' driving**

Figure 63 highlights that participants expected and went on to feel increased frustration when driving with ISA activated compared to a normal car whilst overtaking, driving in fast moving traffic, on a motorway, in light traffic and on rural roads. Again the increased frustration seems typical to those situations which afford the opportunity to speed. The difference between expectations and actual frustration was only significant for driving in a 20mph zone, in bad weather and in poor visibility. Post hoc test revealed a significant difference between the expected frustration decrease and the actual frustration decrease experienced both in the early stages and latter stages of the trial when driving in a 20mph zone. The reduction in frustration when driving in a 20mph zones was significantly less than first expected. Similarly, the decrease in frustration when driving in bad weather and poor visibility was significantly less than participants' expectations following prolonged experienced with the system. With prolonged experience ISA did not serve to reduce the frustration experienced in bad weather and poor visibility as much as participants had expected. Nevertheless ISA did reduce frustration experienced to some extent in all three conditions. For the majority of the other conditions participants expected to feel less frustration driving with ISA compared to driving in a normal car. Although the actual frustration experienced was greater than that expected, scores still remained negative suggesting driving with an ISA car was, on whole, less frustrating than driving in a normal car.

### *4.6.3 Concentration*

It has been suggested that providing drivers with speed limit information and controlling their speed to the posted speed limit may affect drivers' concentration on the driving task and the style in which they drive. Figure 64 highlights that participants anticipation of conflicts, attention to other roads users and other aspects of the driving task (e.g. scanning) increased whilst driving with ISA compared to driving in a normal car. Although the increase in attention was not as high as expected this trend increased with prolonged use suggesting the participants had begun to develop more effective driving styles and search strategies when driving with the ISA system.

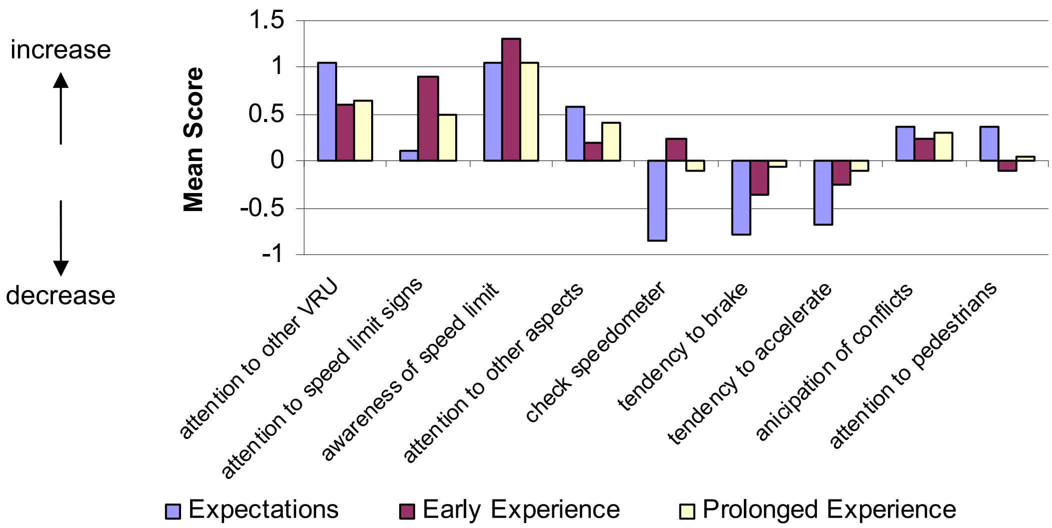


**Figure 64: Perception of change in concentration when driving with ISA compared to 'normal' driving**

Participants' attention to speed limit signs and their awareness of speed limits increased beyond their expectations when driving with ISA compared to normal driving. The subsequent decrease in their awareness following prolonged use may suggest that participants had begun to rely on the system to limit them to legal speed limit without caring what that limit was. Nevertheless, their awareness at this point was still greater than that experienced when driving a normal car. Participants' tendency to check the speedometer had initially increased but with prolonged use, participants again appeared to trust the system and pay less attention to the speedometer than they would during normal driving. Similarly, participants' tendency to brake and accelerate decreased whilst driving with ISA compared to driving in an unsupported car. This effect was weaker with prolonged use however. However it should be noted that differences discussed are minimal and differences across time points were not significant.

### 4.6.4 Driving experience

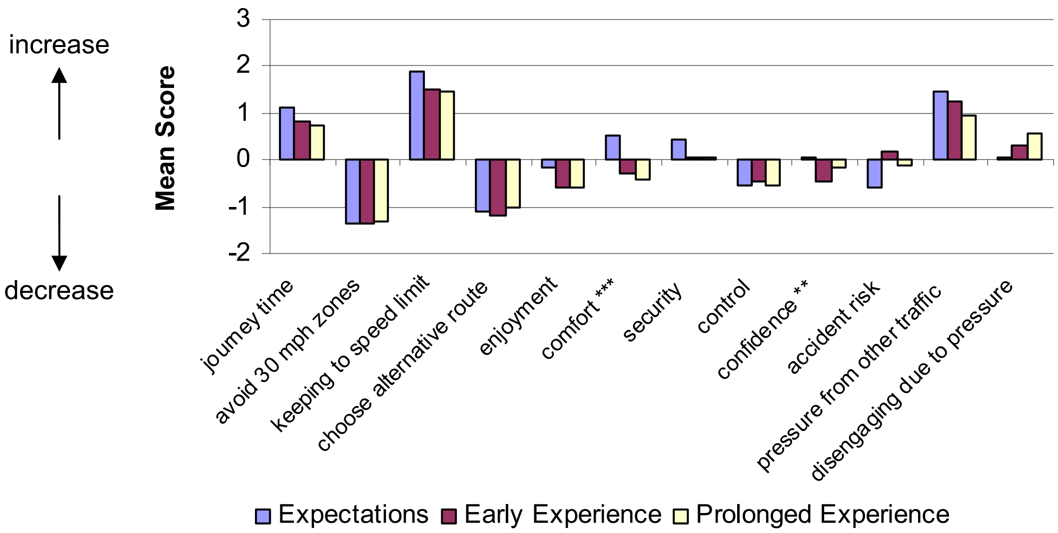


**Figure 65: Perception of changes in driving experience when driving with ISA compared to 'normal' driving**

Compared to 'normal' driving, participants perceived that journey times increased whilst driving with ISA (see Figure 65). This perceived increase in journey times however was less than participants initially expected. Driving with ISA also made it easier to keep to the speed limits compared to driving in a normal car, although this was slightly less easy than expected. Participants had rarely chosen alternative routes in order to avoid ISA warnings or avoided driving in 30mph speed zones. Enjoyment and comfort of driving had decreased when driving with ISA compared to 'normal' driving. Whilst feeling slightly more secure and at a lower risk of being involved in an accident, participants still felt in less control, more apprehensive and under increased pressure from other participants when driving with ISA activated. This increased pressure from other participants also made them more likely to disengage the system. Whilst this pressure seemed to decrease over time, participants' tendency to react to this and disengage the system increased with prolonged experience of the ISA system. These trends were not significant however. Across all scenarios only two significant differences over time were found. Participants experienced significantly less comfort following prolonged use with the ISA system than expected and were significantly less confident driving with the system following early experience than expected.

### 4.6.5 Response to common criticisms

Participants were asked for their opinion on a number of criticisms commonly made regarding the safety of driving with an ISA system.

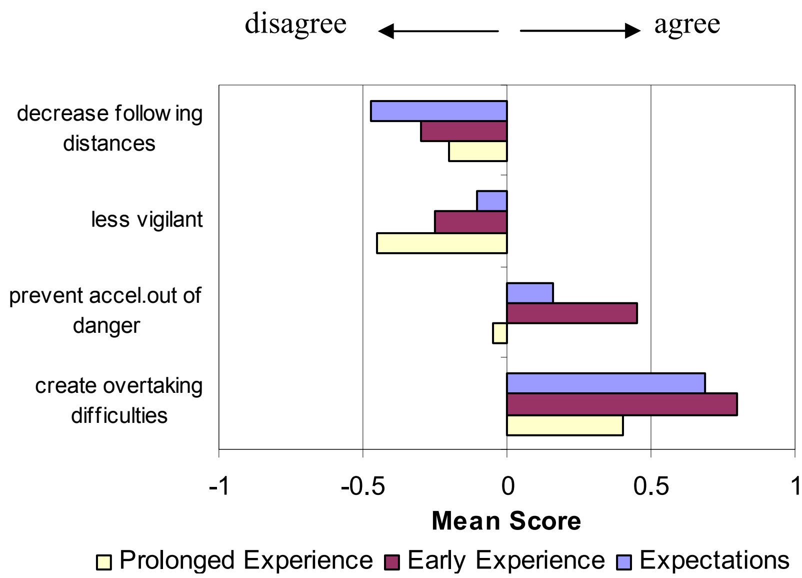


**Figure 66: Participants opinions relating to common criticisms of ISA**

As can be seen in Figure 66, participants disagreed that ISA had made them less vigilant drivers and decreased their adopted following distances. Participants did however, believe that ISA created difficulties when overtaking and prevented the opportunity to accelerate out of danger. Following prolonged experience of ISA however, participants were less likely to believe this. Changes in all opinions over time were not however statistically significant.

Negative behavioural adaptations when ISA control is lost through either GPS dropout or driving on unlimited roads is also a major concern. It has been suggested that drivers may exhibit riskier driving behaviours when the opportunity for unrestricted driving is presented. Two items determined whether participants would driver faster or slower and feel relief or frustration when the ISA system temporarily dropped out. Figure 67 demonstrates that during early experience of the system participants felt more relief and drove slightly faster than they had expected when free to travel at their desired speed. With prolonged experience of the system participants were less likely to driver faster or experience relief, however differences across time points are minimal and non significant.

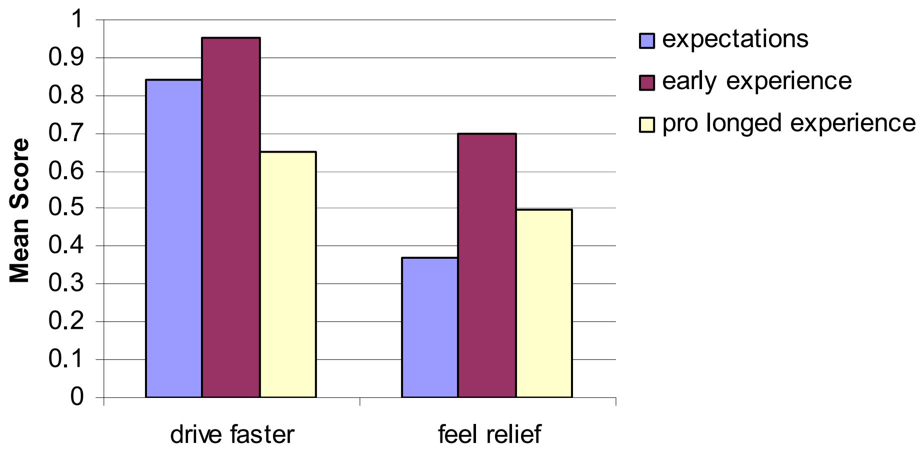


**Figure 67: Participants reactions when ISA unavailable**

## 4.7 Willingness to pay

The cost of ISA to the driver may prove a major obstacle to national roll out. The majority of ISA related studies have therefore sought to determine how much drivers are willing to pay to have an ISA system installed.

In our present study participants were asked whether they were willing to have ISA installed in their vehicle and how much they were willing to pay. Thirty six percent of participants were willing to have ISA installed in their vehicles if its use was voluntary. Participants' willingness to pay for the system ranged from paying nothing to £500. On overage participants were willing to pay £99. Fifty-three percent of participants approved of the compulsory fitting of ISA to all new vehicles and 58% agreed to mandatory introduction of ISA for *all* participants. Those who disagreed tended to approve of targeting ISA at specific high risk groups. Sixty-three percent approved of the mandatory introduction for novice drivers, 75% for the introduction for speed offenders and 38% for the introduction for professional drivers. Participants were unsure of the likelihood of the actual implementation of ISA throughout the UK (see Table 28). Prior to experience with the system participants slightly disagreed that ISA was a system unlikely to be put into operation throughout the UK, however with actual experience opinion shifted slightly as participants began to agree that a national roll out of ISA was unlikely. Again however responses centre around the mid point reflecting relatively neutral responses.

**Table 28: "ISA is a system that will probably never be put into operation throughout the UK: disagree-agree"**

| | Expectations | Early experience | Prolonged experience |
|---|---|---|---|
| Mean | −0.26 | 0.05 | 0.05 |

# 5. OBSERVATION DRIVES

## 5.1 Introduction

The primary purpose of the observation drives was to assess driver behavioural changes across the trial phases by means of indicators not available from the logged data. Participants were accompanied by two trained observers around a predetermined evaluation route on four separate occasions. Since the four drives were carried out on an identical route, it also provided an opportunity to assess the effect of the ISA system on trip related measures. The methodology was identical to the one developed for Field Trial 1 (Lai et al, 2005). A brief description is provided as follows.

The trial route was approximately 38 miles long covering a variety of driving environments (urban, rural, and motorway), road layouts (i.e. single and dual carriageway), and speed zones (i.e. 30, 40, 50, 60, and 70 mph). The drives were carried out at the end of Month 1 (OB1), Month 2 (OB2), Month 5 (OB3) and Month 6 (OB4). Driver behaviour was recorded using the Wiener Fahrprobe technique (Risser, 1985) during the drive and driver mental workload was assessed via NASA-RTLX at the end of the drive (Byers et al, 1989).

## 5.2 Results

### *5.2.1 Trip related measures*

Three important trip related measures were examined to confirm the effect of ISA intervention. Figure 68 demonstrates that ISA led to reduced maximum speed; the significance of the difference is confirmed by the test results of repeated measures ANOVA, as depicted in Table 29.

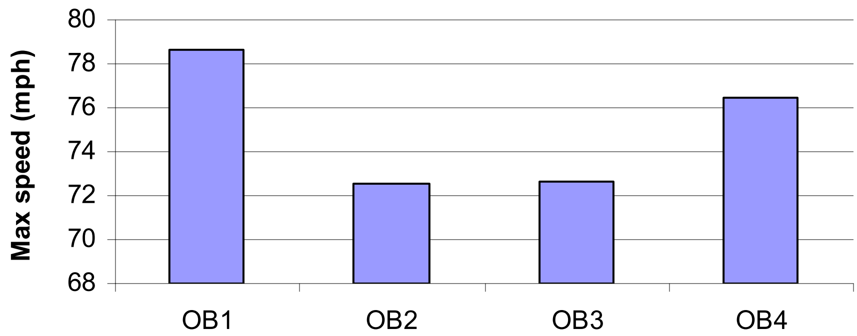


**Figure 68: Comparison of maximum speed across trial phases**

The other two measures inspected were mean trip duration and fuel consumption Although there were no statistical significance revealed by the ANOVAs with respect to these two measures, as reported in Table 29, there was an underlying trend that ISA seemed to have facilitated fuel economy. When the sample size is increased (i.e. more cars on the roads are equipped with ISA), it is likely that the differences in fuel consumption across trial phases will become statistically significant. It is also worth noting that the analysis of fuel consumption presented in Section 3.3 was based on all trips recorded during the trial with no warranty that trip characteristics were comparable across phases and hence did not reveal clear trends. The analysis of fuel consumption described in this section was based on identical trips and therefore other factors which may affect fuel economy among trips were eliminated.

**Table 29: Results of ANOVA and post-hoc t-test of trip related measures**

| | OB1 | OB2 | OB3 | OB4 | Repeated measures ANOVA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | *p* value | Post-hoc t-test | OB2 | OB3 | OB4 |
| Mean trip duration (Min) | 65.66 | 65.73 | 65.44 | 65.34 | F(3,57) = 0.06 | 0.981 | OB1 | × | × | × |
| | | | | | | | OB2 | | × | × |
| | | | | | | | OB3 | | | × |
| Mean maximum speed (MPH) | 78.66 | 72.55 | 72.64 | 76.41 | F(3,57) = 12.84 | < 0.0005** | OB1 | ** | ** | × |
| | | | | | | | OB2 | | × | ** |
| | | | | | | | OB3 | | | ** |
| Fuel consumption (MPG) | 46.95 | 47.60 | 47.97 | 47.30 | F(3,54) = 1.46 | 0.235 | OB1 | × | × | × |
| | | | | | | | OB2 | | × | × |
| | | | | | | | OB3 | | | × |

Note: 1. ** denotes the mean difference is significant at the 0.01 level
2. × denotes the mean difference is not significant.

### *5.2.2 Observed driving behaviour*

Figure 69 illustrates mean Wiener Fahrprobe scores across the four Observation Drives, which shows a significant drop in the number of observed negative behaviour from OB1 to OB2, a further slight drop from OB2 to OB3, then an increase from OB3 to OB4. The ANOVA test results presented in Table 30 reveal that the Wiener Fahrprobe scores recorded when ISA was turned on (i.e. OB2 and OB3) were reliably lower than when ISA was turned off. In addition, the Wiener Fahrprobe score from OB4 was reliably lower than OB1, which indicates a carry-over effect of ISA intervention on the participants' negative driving behaviour. However, duration of the carry-over effect was not able to be fully inspected due to the trial design (i.e. only one month in Phase 3).

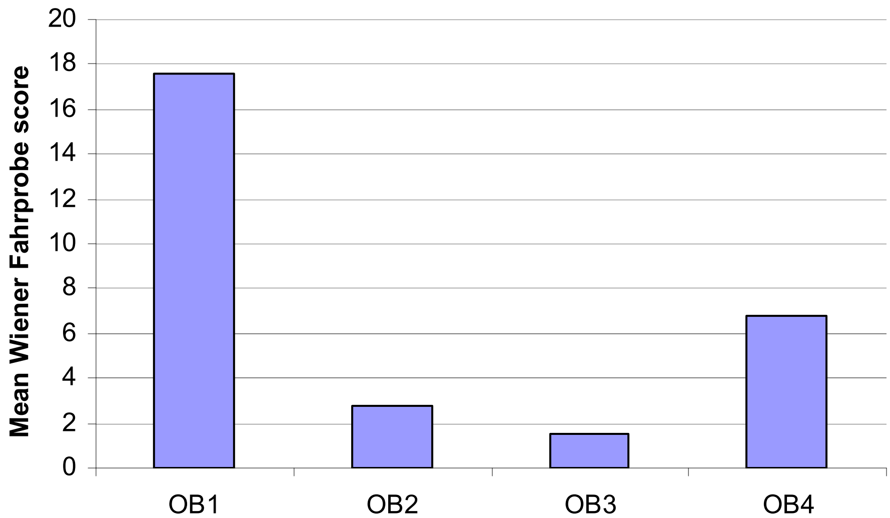


**Figure 69: Mean Wiener Fahrprobe score across trial phases**

**Table 30: Results of ANOVA and post-hoc t-test of Wiener Fahrprobe score across trial phases**

| | OB1 | OB2 | OB3 | OB4 | Repeated measures ANOVA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | *p* value | Post-hoc t-test | | | |
| Mean Wiener Fahrprobe score | 17.6 | 2.8 | 1.5 | 6.8 | F(3,57) = 30.024 | < 0.0005** | | OB2 | OB3 | OB4 |
| | | | | | | | OB1 | ** | ** | ** |
| | | | | | | | OB2 | | × | * |
| | | | | | | | OB3 | | | ** |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant.

Figure 70 shows two negative behaviours recorded on the Wiener Fahrprobe forms, in which the bars stand for total frequency of the negative behaviour observed from all participants rather than mean values. As indicated by the left half of the figure, participants showed considerable improvement in inappropriate choice of speed in response to road geometry when ISA was turned on. The right half of the figure suggests a reduction in frequency of abrupt brake after ISA was switched on.

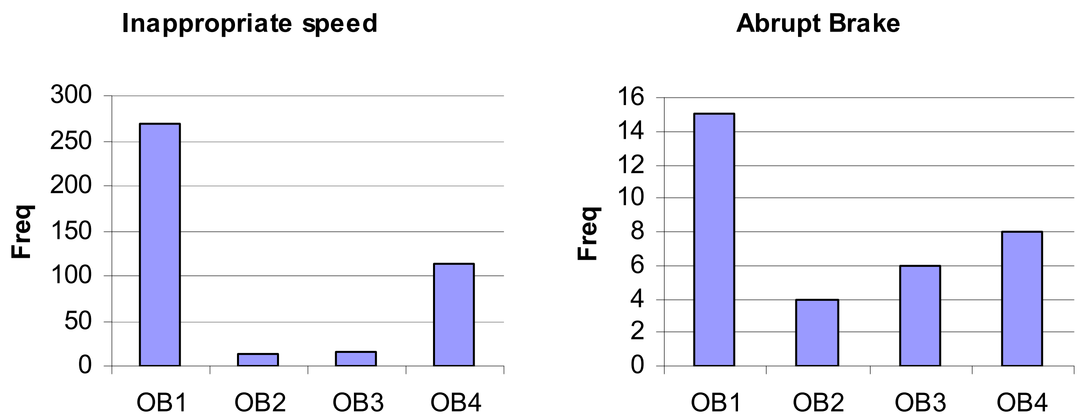


**Figure 70: Observed negative driving behaviour across trial phases**

Figure 71 presents comparison of mean Wiener Fahrprobe scores across the four observation drives with respect to demographic groups, which reveals similar patterns across groups, i.e. the ISA system led to fewer negative driving behaviours or reduced occurrence of negative driving behaviour regardless of a participant's demographic characteristics. The significance of the changes over time was confirmed by repeated measures ANOVA as presented in Table 31. However, the carry-over effect of the ISA intervention seemed to be dependent on participants' demographic characteristics. When ISA control was removed, younger participants and intenders appeared to have resumed their negative driving habits more quickly than their counterparts. The differences between the two gender groups were not as prominent as age or intention groups. In addition, the sample structure with respect to gender grouping was biased (i.e. 3 females against 17 males, and 2 out of the 3 females were intenders), and therefore the gender differences revealed in Figure 71 are not considered to be statistically reliable.

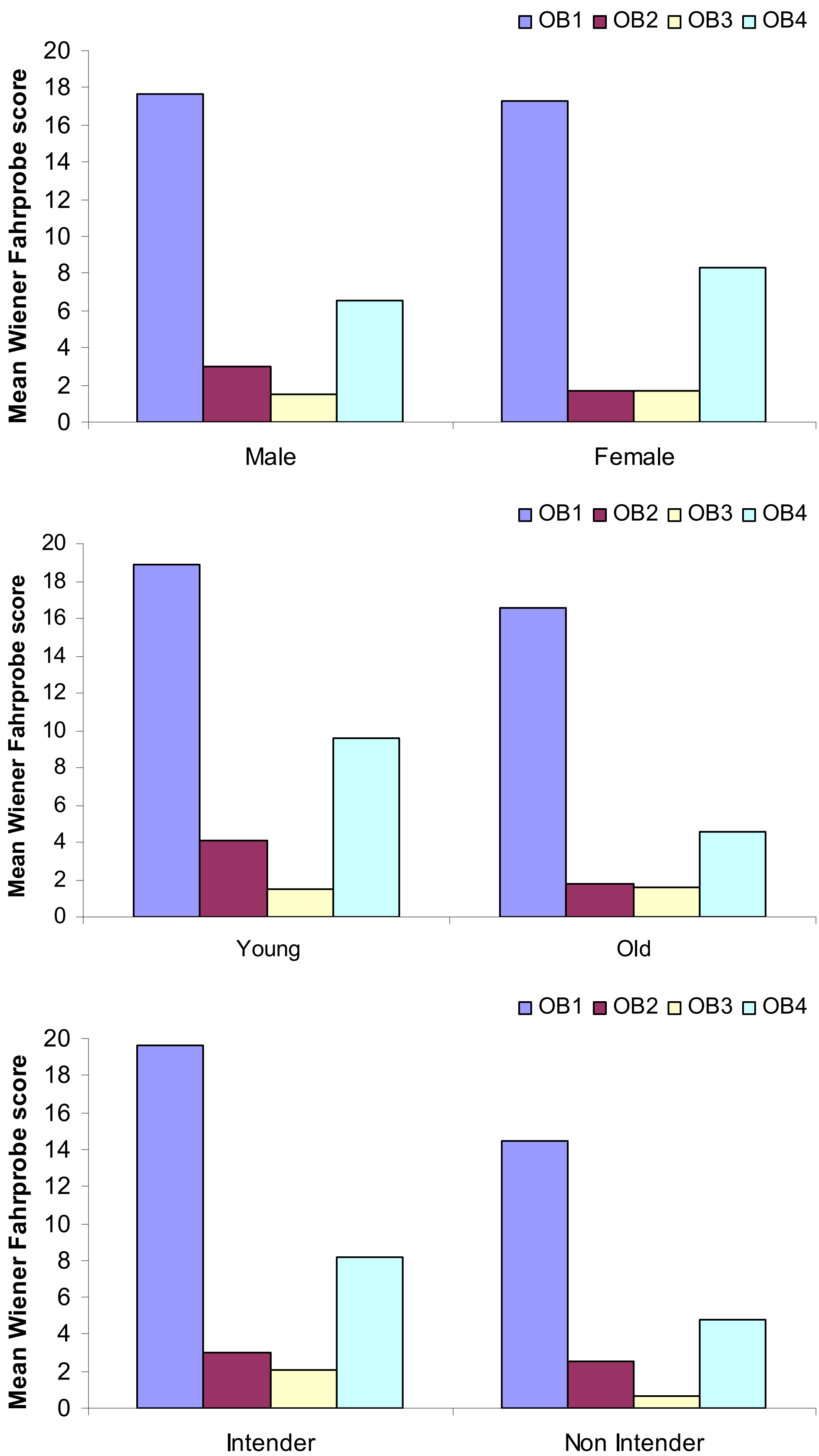


**Figure 71: Mean Wiener Fahrprobe score across trial phases in terms of demographic groups**

**Table 31: Results of ANOVA and post-hoc t-test of Wiener Fahrprobe score across trial phases in terms of demographic groups**

| Demographic group | | OB1 | OB2 | OB3 | OB4 | Repeated measures ANOVA | | | Post-hoc t-tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *F* statistic | significance | Effect size | | OB2 | OB3 | OB4 |
| Gender | Male | 17.65 | 3.00 | 1.47 | 6.53 | F(3,48) = 22.19 | < 0.0005** | 0.581 | OB1 | ** | ** | ** |
| | | | | | | | | | OB2 | | × | × |
| | | | | | | | | | OB3 | | | ** |
| | Female | 17.33 | 1.67 | 1.67 | 8.33 | F(3,6) = 19.00 | 0.002** | 0.905 | OB1 | * | * | × |
| | | | | | | | | | OB2 | | × | * |
| | | | | | | | | | OB3 | | | ** |
| Age | Young | 18.89 | 4.11 | 1.44 | 9.56 | F(3,24) = 11.41 | < 0.0005** | 0.588 | OB1 | ** | ** | * |
| | | | | | | | | | OB2 | | × | × |
| | | | | | | | | | OB3 | | | ** |
| | Old | 16.55 | 1.73 | 1.55 | 4.55 | F(3,30) = 19.87 | < 0.0005** | 0.665 | OB1 | ** | ** | ** |
| | | | | | | | | | OB2 | | × | × |
| | | | | | | | | | OB3 | | | * |
| Intention to speed | Intender | 19.67 | 3.00 | 2.08 | 8.17 | F(3,33) = 21.83 | < 0.0005** | 0.665 | OB1 | ** | ** | ** |
| | | | | | | | | | OB2 | | × | * |
| | | | | | | | | | OB3 | | | * |
| | Non intender | 14.50 | 2.50 | 0.63 | 4.75 | F(3,21) = 8.21 | 0.001** | 0.540 | OB1 | * | * | * |
| | | | | | | | | | OB2 | | × | × |
| | | | | | | | | | OB3 | | | * |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant.

### *5.2.3 Subjective mental workload*

As RTLX contains multiple scales, reliability analysis was carried out to confirm internal consistency among the six rating scales based on inter-item correlation; the results are presented in Table 32. The inter-item correlation between RTLX's sub scales was strong in OB1 and OB2, but was weaker in OB3 and OB4. It is worth noting that stronger inter-item correlation suggests that participants rated their perceived workload more consistently across the six workload dimensions, while weaker inter-item reliability suggests that participants showed stronger feelings on certain workload dimensions over the rest, but it does not invalidate the data.

**Table 32: Reliability scores for NASA-RTLX measures**

| | OB1 | OB2 | OB3 | OB4 |
|---|---|---|---|---|
| Cronbach's Alpha (α) | 0.551 | 0.392 | 0.663 | 0.373 |

Figure 72 shows the overall workload scores across trial phases, which indicates that workload increases when driving under the ISA system. Changes in the perceived workload across trial phases suggest that participants initially felt the driving task became more demanding in the presence of the ISA system (i.e. workload score increased from OB1 to OB2), but with prolonged experience, they gradually adapted to the system and workload decreases accordingly (i.e. workload score dropped slightly from OB2 to OB3). When the ISA system was no longer present, participants' perceived workload went back to similar levels to the baseline (i.e. comparing OB4 against OB1). To confirm statistical significance of the changes in participants' perceived workload, repeated measures ANOVA with gender, age and intention group serving as between-subject factors was carried out. The results indicated that the changes over time were non-significant.

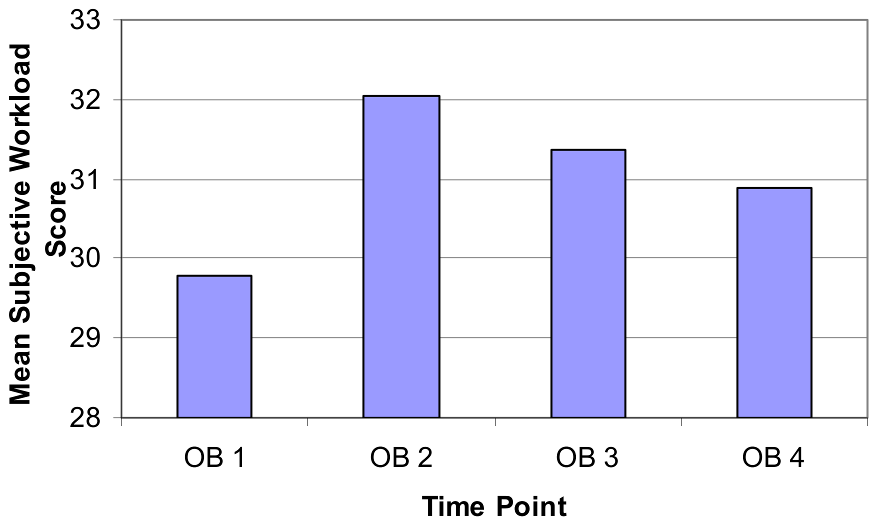


**Figure 72: Mental workload scores over time**

Figure 73 presents the mean scores of individual workload dimensions across the trial phases, which demonstrates a very similar pattern to that for overall workload scores as shown in Figure 72. Participants' perceived workload increased when ISA was introduced and decreased when ISA control was removed.

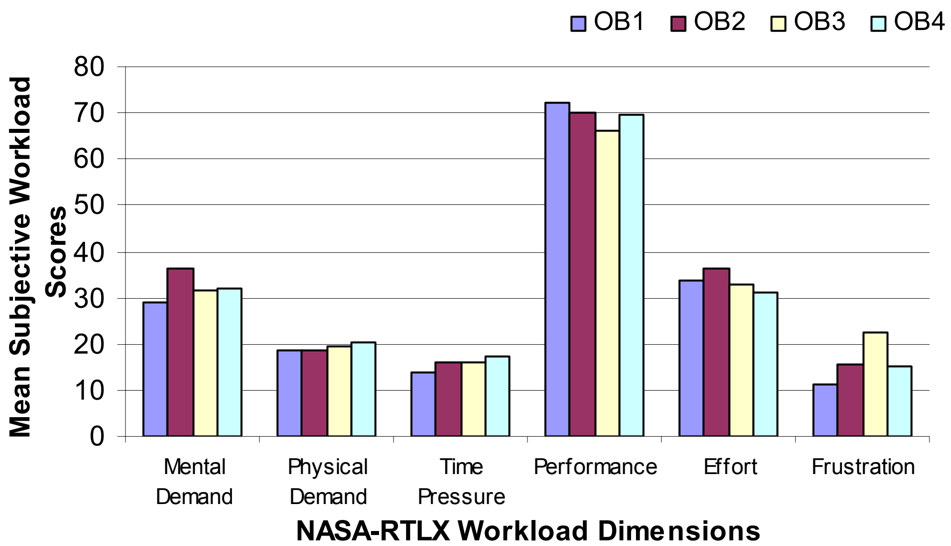


**Figure 73: Individual dimension workload scores over time**

Repeated measures ANOVA with gender, age and intention group serving as between-subject factors was employed to confirm the changes in workload scores over time. However, none of the workload dimensions showed significant effect over time.

## 5.3 Discussion

The data collected from the observation drives have demonstrated some distinctive effect of introducing ISA on driver behaviour as follows.

- Reduced overall negative driving behaviour
- Reduced frequency of inappropriate choice of speed
- Reduced maximum vehicle speed
- Reduced frequency of abrupt brake

ISA is likely to improve fuel economy. Although the effect was not proved to be statistically significant based on the data from this trial, more reliable evidence may be revealed following the availability of more data from the remaining due to the increase in the sample size.

Carry-over effect of the ISA intervention seemed to be dependent on participants' demographic characteristics. When ISA control was removed, younger participants and intenders appeared to have resumed their negative driving habits more quickly than their counterparts. Since the sample structure with respect to gender grouping was biased (i.e. 3 females against 17 males, and 2 out of the 3 females fell into the intenders group), and the gender differences derived from the observation drives are not regarded to be representative of the whole population.

Although changes in driver perceived workload across trial phases were not statistically significant, there were some indications of increased workload when ISA was turned on, which was associated with an increase in mental demand, time pressure, effort, and frustration.

# 6. CONCLUSIONS AND IMPLICATIONS

## 6.1 Behavioural changes

The ISA system was observed to have a distinctive effect in terms of the transformation of the speed distribution across all speed zones except the 20 and 60 mph zones. This means that speeds over the speed limit and in particular very high exceeding of the limit were curtailed. There was not enough driving on 20 mph roads to produce significant results. On the 60 mph roads, speeding behaviour was already rare in the pre period (the first month), so it is not surprising that there was little change with ISA. The lack of speeding on these roads is presumably due to traffic and road geometry conditions, and is in line with national data. When ISA was switched on, a large proportion of the speed distribution initially spread over the speed limit was shifted to around or below the speed limit. Analysis of various statistics related to speed (mean, 85th percentile, etc.) revealed a 'V' shape across trial phases, i.e. the statistic goes down from Phase 1 to Phase 2, then up from Phase 2 to Phase 3. This pattern is especially prominent with respect to high percentiles of the speed distribution, which are strong indicators of speeding behaviour. ISA has not only diminished excessive speeding, but also led to a reduction in speed variation, especially in the urban area where 30 and 40 mph speed limits apply. This delivers positive implications for a reduction in accident occurrence as a result of ISA intervention. Another positive effect of ISA is to be found in the carry-over effect: there was less speeding in the after period than in the pre period indicating that the driver had been trained by the experience of ISA to greater compliance with speed limits. It is of course not known how long this change in behaviour might persist.

The use of an overridable ISA system also provides an opportunity to demonstrate potential resistance from the driving population against its implementation, based on true behaviour instead of opinion. This group of drivers had a greater propensity to override the ISA on 70 mph roads (15.1% of distance) than on roads with a lower speed limit. This may in part be attributable to their work environment. As Leeds City Council employees, the need to comply with speed limits on urban roads may have been inculcated into them. But rates of override on urban roads are still of concern: on 30 mph roads ISA was overridden for 8.4% of distance travelled and on 40 mph roads for 7.3%. These are the roads where drivers are most likely to encounter conflicts with vulnerable road users such as pedestrians and cyclists than in the rest of speed zones.

In terms of demographic groups, younger drivers and drivers who intend to break speed limits overrode the system more often than their counterparts. Thus there is a tendency for ISA to be overridden more by those drivers who in safety terms stand to benefit most from using it. As with other safety systems (e.g. seatbelts), there is therefore a tendency for those who need it most to use it least. This suggests that there may be a role for incentives to keep ISA active and discouragement of overriding when ISA is deployed on a voluntary or fleet basis.

In addition to improved speed limit compliance, ISA also contributes to diminished negative driving behaviour, as well as reduced occurrence of inappropriate choice of speed and abrupt brake, as revealed by the observation drives.

## 6.2 Attitudinal changes

Intentions to exceed the speed limit on motorways and urban roads decreased following experience with the ISA system. Attitudes to speeding on urban roads became slightly more negative with ISA. Attitudes to speeding on residential roads were even more negative, but became slightly less negative following experience with the system. Unfortunately, attitudes towards speeding on a motorway were positive and became more favourable over time. Although the influence of ISA on attitudes and intentions was modest and weakened participants' perceptions of the legal implications of speeding, the system did serve to educate participants that speeding does not necessarily reduce journey times. This is especially important given that safe driving is often compromised in order to save time. Pressure to keep within the speed limits was lowest for the motorway and participants' spouse/partners were identified as the most influential referents. The portrayal of a partner's disapproval of speeding is therefore key to any safety campaign. Participants were also unlikely to regret speeding on a motorway or urban road. Throughout the analysis cognitions relating to speeding on a motorway were identified as the most the important targets for intervention. Cognitions correlated weakly with behaviour measures. However cognitions reported following experience with the ISA system correlated reasonably well with behaviour during Phase 3, particularly for the motorway scenario. Those who expressed favourable attitudes towards speeding, believed more positive than negative outcomes would results from speeding, had frequently exceeding the limit it in the past and perceived less risk in speeding were more likely to speed on motorways. It is important therefore that safety campaigns highlight the negative outcomes of speeding (such as fines, accident risk) and emphasise the risks associated with driving at high speeds.

Self-reported driving errors and lapses both decreased with ISA and this effect persisted after ISA was switched off. Despite an initial dip in acceptability, the rating of the ISA system in terms of usefulness and satisfaction, both improved over time. Usefulness may represent a social utility construct, whereas satisfaction has more to with fulfilment of personal goals. It is encouraging that satisfaction and usefulness ratings were steadily improving with experience.

Participants tended to feel at increased risk and frustration in those situations (e.g. on a motorway, in fast moving and light traffic) which afforded the greatest opportunity to speed. Overtaking was raised also raised as a concern. Nevertheless in the majority of driving situations, participants did feel at less risk when driving with ISA compared to a normal car and experienced less frustration. Similarly participants believed that attention to both the speed limits and potential hazards (e.g. other road users, pedestrians) and conflicts had increased. ISA seems to have raised participants' perceived safety and encouraged participants to develop more effective driving styles.

Support for the implementation of ISA was reasonably strong. Thirty-six percent of participants were willing to have ISA installed in their vehicles if its use was voluntary. Moreover 53% agreed with the compulsory fitting of ISA to all new vehicles and 58% agreed to the mandatory introduction of ISA for all drivers. Those who disagreed were mostly in favour of ISA for speed offenders.

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# APPENDIX A: HARDWARE AND SOFTWARE REVISIONS PRIOR TO LAUNCHING TRIAL 2

## A.1 Software Changes

**Vehicle Control Unit**

The development of the VCU software was completed with version 2.07. Version 2.07 has been used in all of the trials and was implemented from 20 February 2004. Intermediate versions of the software were produced and version 2.07 includes all of the following changes that were introduced to remedy problems identified from running the cars during 2003:

- The time before re-enactment of ISA control after E-override when the road speed is below limit increased from 5 seconds to 10 seconds to enable manoeuvre to be completed.
- The time delay before declaring error 4 increased from 30 to 60 seconds to accommodate variations in start up time between the two computers.
- The software bug fixed that gave following symptoms: dead throttle, blank ISA circle, vibrating accelerator even though the speed is less than 20 mph and the ISA brake applied. It only occurred at specific locations after start-up when the first link with a valid speed limit also has an ambiguous forward speed limit.
- Error Code 5 added when Navteq error 05 appeared in the in key off message to indicate that "GPS time invalid" had been experienced.
- Data downloading message introduced.
- Pedal vibration disabled when E-override is activated.
- ISA control only activated when road speed is within 10% of speed limit.
- The minimum ISA brake on-time set to 1 second. The value at which the brake should activate changed from 5mph above the speed limit to 2% above the speed limit.
- During ISA control, the point at which the throttle pedal vibrates increased to 40% (from 25%) over the calculated demand to maintain the vehicle speed at the speed limit.

**Navteq software**

Navteq Speedadvisor software version 3.41P was introduced after 27 January 2004. This version included the fix for the "frozen speed limit" when an invalid GPS time was encountered.

## A.2 Hardware Changes

Hardware version 1.1 was implemented in March 2004, which improved electrical supply to the ISA system:

- The Skoda car battery was replaced with a heavy duty battery, "Motaquip VBZ3", to increase maximum current draw.
- The power supply board modified by bypassing diode D2 to improve charging of auxiliary batteries.
- The "start on door open" signal removed so that the system starts with ignition key-on to avoid draining the batteries when the door is opened but the engine is not started.
- A hardware switch to turn off the power supply to the computers 13 minutes after ignition off was installed. This ensures that any computer which has failed to shutdown correctly after the allotted 10 minutes does not keep running. This change ensured that the main car battery

is not discharged if one of the computers locks up and that the computers start up correctly for the next journey.

- A hardware switch that does not allow the computers to boot up until the engine speed exceeds 1000 rpm. The vehicle electrical system is then at full capability and this should reduce the problems of disk drives not starting up correctly due to a dip in supply voltage during engine cranking.

# APPENDIX B: ANOVA RESULTS FOR KEY STATISTICS OF THE SPEED DISTRIBUTION

**Table B1: ANOVA results for mean speed by gender**

| Gender group | Speed zone | Mean | | | Repeated measures ANOVA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Phase 1 | Phase 2 | Phase 3 | *F* statistic | significance | Effect size | Post-hoc t-tests | | |
| Male | 20 | 21.10 | 19.04 | 21.65 | F(2,12) = 1.10 | 0.364 | 0.155 | | PH2 | PH3 |
| | | | | | | | | PH1 | * | × |
| | | | | | | | | PH2 | | × |
| | 30 | 28.48 | 26.91 | 27.91 | F(2,32) = 11.62 | < 0.0005** | 0.421 | | PH2 | PH3 |
| | | | | | | | | PH1 | ** | × |
| | | | | | | | | PH2 | | ** |
| | 40 | 35.13 | 34.13 | 35.13 | F(2,32) = 3.69 | 0.036* | 0.187 | | PH2 | PH3 |
| | | | | | | | | PH1 | ** | × |
| | | | | | | | | PH2 | | * |
| | 50 | 47.49 | 45.72 | 46.18 | F(2,32) = 2.74 | 0.080 | 0.146 | | PH2 | PH3 |
| | | | | | | | | PH1 | * | × |
| | | | | | | | | PH2 | | × |
| | 60 | 44.36 | 44.50 | 44.58 | F(2,32) = 0.04 | 0.959 | 0.003 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | 70 | 64.91 | 62.64 | 63.54 | F(2,32) = 1.36 | 0.272 | 0.078 | | PH2 | PH3 |
| | | | | | | | | PH1 | * | × |
| | | | | | | | | PH2 | | × |
| Female | 20 | 22.96 | 21.60 | 21.70 | F(2,2) = 2.11 | 0.321 | 0.679 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | 30 | 28.96 | 27.72 | 28.82 | F(2,4) = 8.45 | 0.037* | 0.809 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | * |
| | 40 | 35.13 | 34.17 | 36.14 | F(2,4) = 4.67 | 0.090 | 0.700 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | 50 | 46.29 | 46.46 | 47.32 | F(2,4) = 0.32 | 0.746 | 0.136 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | 60 | 46.84 | 47.16 | 48.41 | F(2,4) = 0.63 | 0.580 | 0.238 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | 70 | 68.64 | 65.40 | 67.12 | F(2,4) = 0.35 | 0.721 | 0.151 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table B2: ANOVA results for the 85th percentile of the speed distribution by gender**

| Gender group | Speed zone | Mean | | | Repeated measures ANOVA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Phase 1 | Phase 2 | Phase 3 | *F* statistic | significance | Effect size | Post-hoc t-tests: PH1 vs PH2 | PH1 vs PH3 | PH2 vs PH3 |
| Male | 20 | 26.34 | 23.64 | 25.88 | F(2,12) = 0.90 | 0.431 | 0.131 | * | × | × |
| | 30 | 36.32 | 32.30 | 35.46 | F(2,32) = 27.96 | $< 0.0005^{**}$ | 0.636 | ** | × | ** |
| | 40 | 44.27 | 41.91 | 43.65 | F(2,32) = 6.30 | $0.005^{**}$ | 0.283 | ** | × | × |
| | 50 | 56.95 | 53.18 | 54.69 | F(2,32) = 3.69 | $0.036^{*}$ | 0.187 | * | × | × |
| | 60 | 55.48 | 55.85 | 55.20 | F(2,32) = 0.27 | 0.765 | 0.017 | × | × | × |
| | 70 | 77.86 | 73.30 | 75.88 | F(2,32) = 5.09 | $0.012^{*}$ | 0.241 | ** | × | × |
| Female | 20 | 29.49 | 27.18 | 29.97 | F(2,2) = 1.17 | 0.461 | 0.539 | × | × | × |
| | 30 | 38.18 | 33.38 | 37.98 | F(2,4) = 77.33 | $0.001^{**}$ | 0.975 | ** | × | ** |
| | 40 | 46.20 | 41.56 | 46.70 | F(2,4) = 16.02 | $0.012^{*}$ | 0.889 | × | × | ** |
| | 50 | 54.89 | 54.00 | 56.91 | F(2,4) = 1.30 | 0.367 | 0.394 | × | × | × |
| | 60 | 57.33 | 57.48 | 57.25 | F(2,4) = 0.01 | 0.991 | 0.005 | × | × | × |
| | 70 | 79.43 | 73.33 | 78.00 | F(2,4) = 1.19 | 0.392 | 0.374 | ** | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table B3: ANOVA results for mean speed between age groups**

| Age group | Speed zone | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | PH1–PH2 | PH1–PH3 | PH2–PH3 |
| Young | 20 | 23.40 | 21.10 | 21.21 | F(2,6) = 0.68 | 0.543 | 0.184 | × | × | × |
| | 30 | 29.02 | 27.27 | 28.49 | F(2,16) = 17.79 | < 0.0005** | 0.690 | ** | × | ** |
| | 40 | 34.90 | 33.53 | 35.26 | F(2,16) = 11.03 | 0.001** | 0.580 | ** | × | ** |
| | 50 | 47.99 | 46.21 | 46.79 | F(2,16) = 1.73 | 0.209 | 0.178 | × | × | × |
| | 60 | 46.20 | 46.60 | 46.98 | F(2,16) = 0.27 | 0.768 | 0.032 | × | × | × |
| | 70 | 67.07 | 64.05 | 67.94 | F(2,16) = 3.09 | 0.073 | 0.279 | * | × | × |
| Old | 20 | 20.00 | 18.41 | 22.03 | F(2,8) = 1.91 | 0.210 | 0.323 | × | × | × |
| | 30 | 28.16 | 26.84 | 27.68 | F(2,20) = 4.25 | 0.029* | 0.298 | ** | × | × |
| | 40 | 35.32 | 34.62 | 35.30 | F(2,20) = 0.86 | 0.438 | 0.079 | × | × | × |
| | 50 | 46.75 | 45.51 | 45.99 | F(2,20) = 0.73 | 0.496 | 0.068 | × | × | × |
| | 60 | 43.53 | 43.50 | 43.66 | F(2,20) = 0.02 | 0.984 | 0.002 | × | × | × |
| | 70 | 64.16 | 62.25 | 60.92 | F(2,20) = 1.70 | 0.208 | 0.145 | × | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table B4: ANOVA results for the 85th percentile of the speed distribution between age groups**

| Age group | Speed zone | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | PH1–PH2 | PH1–PH3 | PH2–PH3 |
| Young | 20 | 28.15 | 26.95 | 25.90 | F(2,6) = 0.33 | 0.729 | 0.100 | × | × | × |
| | 30 | 37.48 | 32.45 | 36.61 | F(2,16) = 57.71 | < 0.0005** | 0.878 | ** | × | ** |
| | 40 | 44.93 | 40.85 | 44.45 | F(2,16) = 28.16 | < 0.0005** | 0.779 | ** | × | ** |
| | 50 | 57.22 | 53.87 | 56.61 | F(2,16) = 2.15 | 0.149 | 0.212 | × | × | * |
| | 60 | 56.23 | 57.33 | 57.29 | F(2,16) = 0.58 | 0.573 | 0.067 | × | × | × |
| | 70 | 80.06 | 74.42 | 79.93 | F(2,16) = 4.53 | 0.028* | 0.362 | ** | × | × |
| Old | 20 | 26.16 | 22.41 | 27.51 | F(2,8) = 4.04 | 0.061 | 0.503 | ** | × | × |
| | 30 | 35.87 | 32.48 | 35.20 | F(2,20) = 10.97 | 0.001** | 0.523 | ** | × | ** |
| | 40 | 44.26 | 42.69 | 43.83 | F(2,20) = 1.39 | 0.271 | 0.122 | * | × | × |
| | 50 | 56.17 | 52.83 | 53.73 | F(2,20) = 1.86 | 0.182 | 0.157 | × | × | × |
| | 60 | 55.37 | 55.09 | 54.05 | F(2,20) = 0.87 | 0.436 | 0.080 | × | × | × |
| | 70 | 76.48 | 72.39 | 73.14 | F(2,20) = 3.74 | 0.042* | 0.272 | ** | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table B5: ANOVA results for mean speed between intention groups**

| Intention group | Speed zone | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | PH1–PH2 | PH1–PH3 | PH2–PH3 |
| Intender | 20 | 21.88 | 19.57 | 21.95 | F(2,12) = 1.04 | 0.383 | 0.148 | ** | × | × |
| | 30 | 28.28 | 27.12 | 28.06 | F(2,22) = 5.08 | 0.015* | 0.316 | ** | × | * |
| | 40 | 35.09 | 34.37 | 35.41 | F(2,22) = 1.72 | 0.202 | 0.135 | × | × | × |
| | 50 | 47.84 | 46.52 | 47.57 | F(2,22) = 1.04 | 0.370 | 0.086 | × | × | × |
| | 60 | 43.74 | 43.90 | 44.11 | F(2,22) = 0.10 | 0.909 | 0.009 | × | × | × |
| | 70 | 66.96 | 63.97 | 65.61 | F(2,22) = 1.34 | 0.281 | 0.109 | * | × | × |
| Non intender | 20 | 20.24 | 19.74 | 20.67 | F(2,2) = 1.17 | 0.461 | 0.539 | × | * | × |
| | 30 | 28.95 | 26.90 | 28.02 | F(2,14) = 14.00 | < 0.0005** | 0.667 | ** | × | * |
| | 40 | 35.19 | 33.78 | 35.08 | F(2,14) = 8.31 | 0.004** | 0.543 | ** | × | * |
| | 50 | 46.52 | 44.79 | 44.52 | F(2,14) = 2.33 | 0.133 | 0.250 | × | × | × |
| | 60 | 46.23 | 46.40 | 46.71 | F(2,14) = 0.09 | 0.914 | 0.013 | × | × | × |
| | 70 | 63.23 | 61.68 | 61.78 | F(2,14) = 0.51 | 0.612 | 0.068 | × | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table B6: ANOVA results for the 85th percentile of the speed distribution between intention groups**

<table>
<tr><th rowspan="2">Intention group</th><th rowspan="2">Speed zone</th><th rowspan="2">Phase 1</th><th rowspan="2">Phase 2</th><th rowspan="2">Phase 3</th><th colspan="3">Repeated measures ANOVA</th><th rowspan="2" colspan="3">Post-hoc t-tests</th></tr>
<tr><th>F statistic</th><th>significance</th><th>Effect size</th></tr>
<tr><td rowspan="18">Intender</td><td rowspan="3">20</td><td rowspan="3">27.33</td><td rowspan="3">24.84</td><td rowspan="3">27.25</td><td rowspan="3">F(2,12) = 0.84</td><td rowspan="3">0.454</td><td rowspan="3">0.123</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>*</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">30</td><td rowspan="3">36.21</td><td rowspan="3">32.73</td><td rowspan="3">35.81</td><td rowspan="3">F(2,22) = 17.49</td><td rowspan="3">< 0.0005**</td><td rowspan="3">0.614</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>**</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>**</td></tr>
<tr><td rowspan="3">40</td><td rowspan="3">44.46</td><td rowspan="3">42.21</td><td rowspan="3">44.24</td><td rowspan="3">F(2,22) = 3.15</td><td rowspan="3">0.063</td><td rowspan="3">0.223</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>*</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">50</td><td rowspan="3">57.89</td><td rowspan="3">54.30</td><td rowspan="3">56.77</td><td rowspan="3">F(2,22) = 2.00</td><td rowspan="3">0.160</td><td rowspan="3">0.154</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>*</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">55.05</td><td rowspan="3">55.39</td><td rowspan="3">54.78</td><td rowspan="3">F(2,22) = 0.13</td><td rowspan="3">0.875</td><td rowspan="3">0.012</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">70</td><td rowspan="3">79.58</td><td rowspan="3">74.18</td><td rowspan="3">78.00</td><td rowspan="3">F(2,22) = 4.50</td><td rowspan="3">0.023*</td><td rowspan="3">0.291</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>**</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="18">Non intender</td><td rowspan="3">20</td><td rowspan="3">26.02</td><td rowspan="3">23.00</td><td rowspan="3">25.18</td><td rowspan="3">F(2,2) = 5.37</td><td rowspan="3">0.157</td><td rowspan="3">0.843</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>*</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">30</td><td rowspan="3">37.17</td><td rowspan="3">32.07</td><td rowspan="3">35.87</td><td rowspan="3">F(2,14) = 26.68</td><td rowspan="3">< 0.0005**</td><td rowspan="3">0.792</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>**</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>**</td></tr>
<tr><td rowspan="3">40</td><td rowspan="3">44.72</td><td rowspan="3">41.34</td><td rowspan="3">43.92</td><td rowspan="3">F(2,14) = 18.47</td><td rowspan="3">< 0.0005**</td><td rowspan="3">0.725</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>**</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>**</td></tr>
<tr><td rowspan="3">50</td><td rowspan="3">54.77</td><td rowspan="3">51.80</td><td rowspan="3">52.42</td><td rowspan="3">F(2,14) = 2.23</td><td rowspan="3">0.144</td><td rowspan="3">0.242</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">56.82</td><td rowspan="3">57.17</td><td rowspan="3">56.61</td><td rowspan="3">F(2,14) = 0.18</td><td rowspan="3">0.838</td><td rowspan="3">0.025</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">70</td><td rowspan="3">75.86</td><td rowspan="3">71.99</td><td rowspan="3">73.50</td><td rowspan="3">F(2,14) = 2.11</td><td rowspan="3">0.158</td><td rowspan="3">0.232</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>**</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
</table>

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

# APPENDIX C: ANOVA RESULTS FOR KEY STATISTICS OF QUESTIONNAIRE DATA

**Table C1: ANOVA results for cognitions relating to speeding on a motorway**

<table>
<tr><th rowspan="2"></th><th rowspan="2">TPB</th><th rowspan="2">Phase 1</th><th rowspan="2">Phase 2</th><th rowspan="2">Phase 3</th><th colspan="3">Repeated measures ANOVA</th><th rowspan="2" colspan="3">Post-hoc t-tests</th></tr>
<tr><th>F statistic</th><th>significance</th><th>Effect size</th></tr>
<tr><td rowspan="30">MOTORWAY SCENARIO</td><td rowspan="3">BI</td><td rowspan="3">0.071</td><td rowspan="3">0.329</td><td rowspan="3">0.085</td><td rowspan="3">F(2,28) = 0.102</td><td rowspan="3">0.903</td><td rowspan="3">0.007</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">ATT</td><td rowspan="3">0.595</td><td rowspan="3">0.644</td><td rowspan="3">0.494</td><td rowspan="3">F (2,28) = 0.065</td><td rowspan="3">0.802</td><td rowspan="3">0.005</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">BE</td><td rowspan="3">0.446</td><td rowspan="3">1.176</td><td rowspan="3">0.966</td><td rowspan="3">F (2,28) = 0.435</td><td rowspan="3">0.652</td><td rowspan="3">0.030</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">NBMC</td><td rowspan="3">0.452</td><td rowspan="3">-0.774</td><td rowspan="3">1.119</td><td rowspan="3">F (2,28) = 0.441</td><td rowspan="3">0.648</td><td rowspan="3">0.031</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">PBC</td><td rowspan="3">6.172</td><td rowspan="3">5.989</td><td rowspan="3">5.730</td><td rowspan="3">F (2,28) = 0.656</td><td rowspan="3">0.431</td><td rowspan="3">0.045</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">CBF</td><td rowspan="3">-4.011</td><td rowspan="3">-1.507</td><td rowspan="3">-0.772</td><td rowspan="3">F (2,28) = 2.889</td><td rowspan="3">0.072</td><td rowspan="3">0.171</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">MN</td><td rowspan="3">3.931</td><td rowspan="3">3.858</td><td rowspan="3">3.906</td><td rowspan="3">F (2,28) = 0.005</td><td rowspan="3">0.995</td><td rowspan="3">0.000</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">AR</td><td rowspan="3">-1.456</td><td rowspan="3">-1.795</td><td rowspan="3">-1.489</td><td rowspan="3">F (2,28) = 0.344</td><td rowspan="3">0.629</td><td rowspan="3">0.024</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">PB</td><td rowspan="3">4.467</td><td rowspan="3">3.552</td><td rowspan="3">4.500</td><td rowspan="3">F (2,28) = 0.778</td><td rowspan="3">0.469</td><td rowspan="3">0.053</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
<tr><td rowspan="3">RISK</td><td rowspan="3">4.827</td><td rowspan="3">3.360</td><td rowspan="3">3.835</td><td rowspan="3">F (2,28) = 3.815</td><td rowspan="3">0.034*</td><td rowspan="3">0.214</td><td></td><td>PH2</td><td>PH3</td></tr>
<tr><td>PH1</td><td>×</td><td>×</td></tr>
<tr><td>PH2</td><td></td><td>×</td></tr>
</table>

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

### Table C2: ANOVA results for cognitions relating to speeding on an urban road

| | TPB | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | | | |
| URBAN SCENARIO | BI | -0.925 | -0.819 | -1.852 | F (2,28) = 4.197 | 0.027* | 0.231 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | ATT | -0.246 | -0.122 | -0.190 | F (2,26) = 0.052 | 0.823 | 0.004 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | BE | -1.211 | -1.109 | -0.333 | F (2,28) = 0.909 | 0.415 | 0.061 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | NBMC | 5.967 | 4.295 | 5.319 | F (2,28) = 0.459 | 0.636 | 0.032 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | PBC | 5.799 | 5.279 | 5.683 | F (2,28) = 0.762 | 0.431 | 0.052 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | CBF | -2.578 | -3.031 | -2.835 | F (2,28) = 0.048 | 0.953 | 0.003 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | MN | 5.413 | 5.091 | 5.281 | F (2,28) = 0.206 | 0.815 | 0.015 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | AR | -0.603 | -0.897 | -0.420 | F (2,28) = 0.267 | 0.768 | 0.019 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | PB | 4.600 | 2.585 | 4.466 | F (2,28) = 4.059 | 0.028* | 0.225 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | RISK | 4.982 | 5.089 | 4.376 | F (2,28) = 1.954 | 0.161 | 0.122 | | PH2 | PH3 |
| | | | | | | | | PH1 | × | × |
| | | | | | | | | PH2 | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table C3: ANOVA results for cognitions relating to speeding on a residential road**

| | TPB | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | | | |
| RESIDENTIAL SCENARIO | | | | | | | | | PH2 | PH3 |
| | BI | -2.480 | -1.983 | -2.243 | F(2,28) = 1.037 | 0.368 | 0.069 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | ATT | -2.022 | -1.613 | -1.337 | F (2,28) = 1.899 | 0.170 | 0.127 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | BE | -3.104 | -2.784 | -2.099 | F(2,28) = 0.794 | 0.462 | 0.054 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | NBMC | 8.075 | 5.376 | 4.958 | F (2,28) = 1.223 | 0.309 | 0.080 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | PBC | 5.291 | 5.224 | 5.596 | F(2,28) = 0.513 | 0.604 | 0.035 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | CBF | -3.793 | -2.972 | -4.659 | F (2,28) = 0.421 | 0.661 | 0.029 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | MN | 6.118 | 5.744 | 5.778 | F (2,28) = 0.333 | 0.720 | 0.023 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | AR | 0.227 | -0.134 | 0.677 | F (2,28) = 0.906 | 0.416 | 0.061 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | PB | 5.071 | 3.311 | 3.872 | F (2,28) = 2.393 | 0.110 | 0.146 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | | | | | | | | | PH2 | PH3 |
| | RISK | 5.699 | 3.360 | 3.835 | F (2,28) = 8.424 | 0.005** | 0.376 | PH1 | ** | × |
| | | | | | | | | PH2 | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. × denotes the mean difference is not significant

**Table C4: ANOVA results for cognitions relating to disengaging the ISA system**

| | TPB | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA *F* statistic | significance | Effect size | Post-hoc t-tests | PH2 | PH3 |
|---|---|---|---|---|---|---|---|---|---|---|
| DISENGAGE SCENARIO | BI | -2.304 | -1.528 | -1.690 | F (2,28) = 0.934 | 0.405 | 0.063 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | ATT | -0.148 | 0.212 | 0.114 | F (2,28) = 0.316 | 0.583 | 0.222 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | BE | 1.933 | 2.313 | 2.544 | F (2,28) = 0.279 | 0.606 | 0.020 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | NBMC | 2.022 | -2.359 | 0.828 | F (2,28) = 1.182 | 0.321 | 0.078 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | PBC | 5.371 | 6.712 | 6.345 | F (2,28) = 8.788 | 0.001*** | 0.386 | PH1 | ** | × |
| | | | | | | | | PH2 | | × |
| | CBF | -6.937 | -4.791 | -5.468 | F (2,28) = 0.622 | 0.544 | 0.043 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | MN | 6.053 | 3.976 | 4.185 | F (2,28) = 4.721 | 0.026* | 0.252 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | AR | 0.676 | 0.055 | 0.230 | F (2,28) = 0.457 | 0.510 | 0.032 | PH1 | × | × |
| | | | | | | | | PH2 | | × |
| | RISK | 3.333 | 3.959 | 3.346 | F (2,28) = 0.636 | 0.439 | 0.043 | PH1 | × | × |
| | | | | | | | | PH2 | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C5: ANOVA results for participants' self identity scores**

| TPB | Phase 1 | Phase 2 | Phase 3 | Repeated measures ANOVA *F* statistic | significance | Effect size | Post-hoc t-tests | PH2 | PH3 |
|---|---|---|---|---|---|---|---|---|---|
| SI | 6.222 | 5.815 | 5.789 | F (2,28) = 0.612 | 0.549 | 0.042 | PH1 | × | × |
| | | | | | | | PH2 | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C6: ANOVA results for participants' acceptability ratings of ISA**

| | | Time 1 | Time 2 | Time 3 | Time 4 | Repeated measures ANOVA: *F* statistic | Repeated measures ANOVA: significance | Repeated measures ANOVA: Effect size | Post-hoc t-tests | T2 | T3 | T4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACCEPTABILITY | USE | 1.123 | 0.740 | 0.862 | 0.880 | F (3,42) = 0.837 | 0.424 | 0.056 | T1 | × | × | × |
| | | | | | | | | | T2 | | × | × |
| | | | | | | | | | T3 | | | × |
| | SAT | -0.109 | -0.359 | -0.294 | -0.001 | F(3,42) = 0.582 | 0.458 | 0.040 | T1 | × | × | × |
| | | | | | | | | | T2 | | × | × |
| | | | | | | | | | T3 | | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C7: ANOVA results for participants' propensity to commit lapses, errors and violations**

| | | Time 1 | Time 2 | Time 3 | Time 4 | Repeated measures ANOVA: *F* statistic | Repeated measures ANOVA: significance | Repeated measures ANOVA: Effect size | Post-hoc t-tests | T2 | T3 | T4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DRIVER BEHAVIOUR QUESTIONNAIRE | LAPSE | 0.931 | 0.781 | 0.679 | 0.401 | F (3,39) = 4.708 | 0.007** | 0.266 | T1 | × | × | × |
| | | | | | | | | | T2 | | × | * |
| | | | | | | | | | T3 | | | × |
| | ERROR | 0.496 | 0.132 | 0.138 | 0.168 | F (3,39) = 8.003 | 0.000*** | 0.381 | T1 | * | * | * |
| | | | | | | | | | T2 | | × | × |
| | | | | | | | | | T3 | | | × |
| | VIOL | 0.698 | 0.381 | 0.568 | 0.524 | F (3,39) = 2.763 | 0.064 | 0.175 | T1 | × | × | × |
| | | | | | | | | | T2 | | × | × |
| | | | | | | | | | T3 | | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C8: ANOVA results for participants' perceptions of change in risk when driving with ISA**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | EXP–EAR | EXP–PRO | EAR–PRO |
| RISK | overtaking | 0.420 | 1.398 | 0.716 | F (2,30) = 5.185 | 0.012* | 0.257 | * | × | × |
| | fast moving | 0.112 | 0.825 | 0.697 | F (2,30) = 2.087 | 0.142 | 0.122 | × | × | × |
| | motorway | 0.494 | 0.293 | 0.375 | F (2,30) = 0.102 | 0.754 | 0.007 | × | × | × |
| | 20mph | -1.447 | -1.001 | -0.882 | F (2,30) = 2.351 | 0.113 | 0.135 | × | × | × |
| | major road (40-60mph) | -0.310 | -0.203 | 0.238 | F (2,30) = 0.910 | 0.413 | 0.057 | × | × | × |
| | night-time | -0.656 | -0.387 | -0.359 | F (2,30) = 0.325 | 0.725 | 0.021 | × | × | × |
| | day time | 0.310 | 0.375 | -0.651 | F (2,30) = 8.375 | 0.001*** | 0.358 | × | * | *** |
| | heavy traffic | -0.515 | -0.673 | -0.932 | F (2,30) = 1.088 | 0.313 | 0.068 | × | × | × |
| | light traffic | -0.431 | -0.008 | 0.290 | F (2,30) = 1.554 | 0.228 | 0.094 | × | × | × |
| | bad weather | -0.603 | -0.847 | -0.504 | F (2,30) = 0.929 | 0.406 | 0.058 | × | × | × |
| | poor visibility | -0.609 | -0.807 | -0.495 | F (2,30) = 0.557 | 0.579 | 0.036 | × | × | × |
| | child presence | -1.262 | -1.250 | -0.478 | F (2,30) = 3.793 | 0.034* | 0.202 | × | × | × |
| | ped. crossing | -1.040 | -1.198 | -0.385 | F (2,30) = 4.433 | 0.021* | 0.228 | × | * | × |
| | compl. junction | -0.454 | -0.900 | -0.389 | F (2,30) = 2.047 | 0.147 | 0.120 | × | × | × |
| | built up (30mph) | -0.687 | -0.380 | -0.498 | F (2,30) = 0.440 | 0.517 | 0.028 | × | × | × |
| | rural road (60mph) | 0.130 | 0.387 | 0.133 | F (2,30) = 0.555 | 0.580 | 0.036 | × | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. *** denotes the mean difference is significant at the 0.001 level
3. × denotes the mean difference is not significant

**Table C9: ANOVA results for participants' perceptions of change in frustration for others and themselves when driving with ISA**

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2">Expect</th><th rowspan="2">Early Use</th><th rowspan="2">Prolonged Use</th><th colspan="3">Repeated measures ANOVA</th><th colspan="3" rowspan="2">Post-hoc t-tests</th></tr>
<tr><th>F statistic</th><th>significance</th><th>Effect size</th></tr>
<tr><td rowspan="6">FRUSTRATION</td><td rowspan="3">frustrate myself</td><td rowspan="3">0.137</td><td rowspan="3">0.510</td><td rowspan="3">0.230</td><td rowspan="3">F (2,30) = 0.277</td><td rowspan="3">0.760</td><td rowspan="3">0.018</td><td></td><td>EAR</td><td>PRO</td></tr>
<tr><td>EXP</td><td>×</td><td>×</td></tr>
<tr><td>EAR</td><td></td><td>×</td></tr>
<tr><td rowspan="3">frustrate others</td><td rowspan="3">1.014</td><td rowspan="3">0.990</td><td rowspan="3">0.852</td><td rowspan="3">F (2,30) = 0.044</td><td rowspan="3">0.957</td><td rowspan="3">0.003</td><td></td><td>EAR</td><td>PRO</td></tr>
<tr><td>EXP</td><td>×</td><td>×</td></tr>
<tr><td>EAR</td><td></td><td>×</td></tr>
</table>

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C10: ANOVA results for participants' perceptions of change in frustration across several conditions when driving with ISA**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | EXP – EAR | EXP – PRO | EAR – PRO |
| FRUSTRATION | overtaking | 0.769 | 1.052 | 1.244 | F (2,30) = 0.784 | 0.466 | 0.050 | × | × | × |
| | fast moving | 0.739 | 0.830 | 1.005 | F (2,30) = 0.385 | 0.684 | 0.025 | × | × | × |
| | motorway | 1.127 | 0.722 | 1.131 | F (2,30) = 0.501 | 0.611 | 0.032 | × | × | × |
| | 20mph | -1.512 | -0.393 | 0.118 | F (2,30)=13.691 | 0.000*** | 0.477 | * | *** | × |
| | major road (40-60mph) | 0.223 | -0.083 | -0.074 | F (2,30) = 0.536 | 0.590 | 0.035 | × | × | × |
| | night-time | -0.268 | 0.412 | 0.043 | F (2,30) = 1.434 | 0.254 | 0.087 | × | × | × |
| | day time | 0.234 | 0.262 | 0.000 | F (2,30) = 0.291 | 0.750 | 0.019 | × | × | × |
| | heavy traffic | -0.570 | -0.963 | -0.488 | F (3,30) = 0.781 | 0.467 | 0.049 | × | × | × |
| | light traffic | 0.237 | 0.318 | 0.401 | F (2,30) = 0.417 | 0.663 | 0.027 | × | × | × |
| | bad weather | -1.210 | -0.381 | -0.414 | F (2,30) = 3.774 | 0.035* | 0.201 | × | * | × |
| | poor visibility | -1.159 | -0.367 | -0.408 | F (2,30) = 5.525 | 0.009** | 0.269 | × | * | × |
| | child presence | -1.398 | -0.914 | -0.714 | F (2,30) = 2.994 | 0.065 | 0.166 | × | * | × |
| | ped. crossing | -1.402 | -0.896 | -0.712 | F (2,30) = 2.727 | 0.082 | 0.154 | × | * | × |
| | compl. junction | -1.101 | -0.768 | -0.599 | F (2,30) = 1.019 | 0.373 | 0.064 | × | × | × |
| | built up (30mph) | -0.604 | 0.009 | 0.122 | F (2,30) = 1.434 | 0.254 | 0.087 | × | × | × |
| | rural road (60mph) | 0.546 | 0.568 | 0.241 | F (2,30) = 0.750 | 0.481 | 0.048 | × | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level

**Table C11: ANOVA results for participants' perceptions of change in concentration across several conditions when driving with ISA**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | | | |
| CONCENTRATION | atten. to other road users | 1.085 | 0.978 | 0.927 | F (2,30) = 0.052 | 0.949 | 0.003 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | atten. to speed limit signs | 0.167 | 1.473 | 0.495 | F (2,30) = 1.532 | 0.233 | 0.093 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | awareness of limit | 1.159 | 1.682 | 1.205 | F (2,28) = 1.452 | 0.248 | 0.094 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | atten. to aspects of driving | 0.981 | 0.340 | 0.485 | F (2,30) = 1.299 | 0.272 | 0.080 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | check speedo | -0.201 | -0.283 | -1.012 | F (2,30) = 1.551 | 0.229 | 0.094 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | tendency to brake | -0.907 | -0.820 | -0.277 | F (2,30) = 1.221 | 0.309 | 0.075 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | tendency to accel | -0.755 | -0.557 | -0.295 | F (2,30) = 0.504 | 0.609 | 0.033 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | anticip. of conflicts | 0.768 | 0.598 | 0.892 | F (2,30) = 0.248 | 0.782 | 0.016 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | attent. to pedestrian | 0.259 | -0.091 | 0.006 | F (2,30) = 0.736 | 0.404 | 0.047 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C12: ANOVA results for participants' perceptions of change in driving experience when driving with ISA**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | EXP–EAR | EXP–PRO | EAR–PRO |
| DRIVING EXPERIENCE | journey time | 1.240 | 1.017 | 1.072 | F (2,30) = 0.222 | 0.802 | 0.015 | × | × | × |
| | Alternative route | -1.301 | -0.979 | -1.046 | F (2,30) = 0.261 | 0.772 | 0.017 | × | × | × |
| | Avoid 30mph | -1.455 | -0.994 | -0.806 | F (2,30) = 3.215 | 0.054 | 0.177 | × | × | × |
| | Keep to limit | 1.959 | 1.509 | 1.524 | F (2,30) = 1.264 | 0.297 | 0.078 | × | × | × |
| | enjoyment | -0.196 | -0.834 | -0.546 | F (2,30) = 2.207 | 0.135 | 0.128 | × | × | × |
| | security | 0.417 | 0.227 | 0.052 | F (2,30) = 0.618 | 0.546 | 0.040 | × | × | × |
| | control | -0.574 | -0.334 | -0.570 | F (2,30) = 0.203 | 0.818 | 0.013 | × | × | × |
| | confidence | 0.587 | -0.562 | -0.214 | F (2,30) = 7.299 | 0.003** | 0.327 | * | × | × |
| | accident risk | -0.443 | 0.203 | -0.491 | F (2,30) = 1.920 | 0.169 | 0.113 | × | × | * |
| | comfort | 0.779 | -0.032 | -0.483 | F (2,30) = 8.354 | 0.001*** | 0.358 | × | * | × |
| | pressure from traffic | 1.752 | 1.220 | 1.074 | F (2,30) =1.988 | 0.155 | 0.117 | × | × | × |
| | opt out | -1.180 | -1.141 | -0.983 | F (2,30) = 0.158 | 0.854 | 0.010 | × | × | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C13: ANOVA results for participants' response to common criticisms across time.**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | | | |
| COMMON CRITICISMS | Overtaking difficulties | 0.844 | 0.575 | 0.611 | F (2,30) = 0.106 | 0.900 | 0.007 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | Accel out of danger | -0.43 | 0.454 | -0.288 | F (2,30) = 1.117 | 0.307 | 0.069 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | less vigilant | -0.688 | -0.588 | -0.493 | F (2,30) = 0.066 | 0.801 | 0.004 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | decrease following distances | -0.651 | -1.307 | -0.493 | F (2,30) =1.541 | 0.231 | 0.093 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant

**Table C14: ANOVA results for participants' reactions to ISA 'drop-out' across time**

| | | Expect | Early Use | Prolonged Use | Repeated measures ANOVA | | | Post-hoc t-tests | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *F* statistic | significance | Effect size | | | |
| DROP OUT | drive faster | 1.101 | 1.396 | 0.692 | F (2,30) = 1.705 | 0.199 | 0.102 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |
| | feel relief | 0.390 | 0.777 | 0.396 | F (2,30) = 1.080 | 0.352 | 0.067 | | EAR | PRO |
| | | | | | | | | EXP | × | × |
| | | | | | | | | EAR | | × |

Note:
1. * denotes the mean difference is significant at the 0.05 level
2. ** denotes the mean difference is significant at the 0.01 level
3. *** denotes the mean difference is significant at the 0.001 level
4. × denotes the mean difference is not significant