The effectiveness of an advisory Intelligent Speed Adaptation (ISA) system for Victorian repeat speeders

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Abstract

The Repeat Speeders Trial (RST) aimed to evaluate two interventions to assist Victorian recidivist speeders to reduce speeding: a speed behaviour program and advisory ISA. This paper presents the findings from the on-road trial of ISA. The trial aimed to evaluate the effectiveness of an advisory ISA system, either coupled with demerit point removal or not, in reducing recidivist speeders' speeding behaviour. A total of 86 repeat speeders from Victoria participated in the ISA trial. Forty of the drivers were exposed to advisory ISA as part of their everyday driving for a period of 12 weeks and then monitored via a data logger for a further eight weeks (Speed Alert group). Another group of 46 drivers, who were not exposed to ISA but monitored for 20 weeks, acted as a control group (Speed Data group). Approximately half of the participants in each group, who were selected at random, had three demerits points from their last speeding offence removed from their driving record. When ISA was active, the Speed Alert group had a statistically significant reduction in mean speed, time spent exceeding the speed limit, and the time taken to return to the speed limit when it was exceeded compared to the Speed Data group. When ISA was not active, there was no difference in speeding behaviour between groups. Demerit point removal did not influence the effectiveness of ISA. These results are promising given that this is one of only two studies published worldwide to demonstrate the effectiveness of ISA in a sample of recidivist speeders.

Introduction

Excessive or inappropriate speed remains one of the most common factors contributing to road crashes. In 2011, 1,291 people in Australia died as a result of road crashes (Bureau of Infrastructure, Transport, Regional Economics, 2011). Excessive and inappropriate travel speeds are a factor in around 34% of deaths on Australia's roads and addressing speed-related crashes continues to be a core platform of both State and National road safety strategies in Australia (Australian Transport Council & Australian Transport Safety Bureau, 2011).

Intelligent Speed Adaptation (ISA) is an Advanced Driver Assistance System (ADAS) that warns the driver and/or limits vehicle speed when the driver exceeds the posted speed limit which makes it a promising measure to reduce excessive speeding and speed-related crashes. A number of on-road trials of ISA in passenger cars have now been conducted and these have established that ISA effectively reduces speed, speed variability and speed violations and is particularly effective for reducing speeds at the upper end of the speed distribution (Carsten & Tate, 2000; Jamson, 2006; Jiménez et al., 2008; Regan et al., 2006; Vlassenroot et al., 2007; Wallén Warner & Aberg, 2008; NSW Centre for Road Safety, 2010). This indicates that ISA may be especially useful for changing the behaviour of drivers who speed often. The only other published study of ISA for serious speeders was conducted in the Netherlands in 2011 and found both advisory and limiting ISA to be effective in reducing mean speed (van der Pas, Kessels, Veroude et al., 2014; van der Pas, Kessels, Vlassenroot et al., 2014)

In 2010 VicRoads commenced the Repeat Speeders Trial (RST) which was designed to evaluate the effectiveness of two interventions to assist Victorian recidivist speeders to reduce speeding. The first intervention was an advisory ISA system (SpeedAlert, developed by Smart Car Technologies) while the second involved drivers attending a two-part behavioural intervention program. The

Monash University Accident Research Centre (MUARC) evaluated the outcomes of both sub-trials. This paper presents the evaluation of the ISA component of the RST. The aim of the ISA trial was to evaluate the effectiveness of an advisory ISA system, either coupled with demerit point removal or not, in reducing recidivist speeders' speeding behaviour.

Method

Participants

Drivers were eligible for an invitation to participate in the RST if they held a full current Victorian car licence, and had recently received a three-point Traffic Infringement Notice (TIN) for exceeding the speed limit by 10 km/h or more but less than 25 km/h, resulting in a total of between eight to eleven demerit points. These drivers were at high risk of losing their licence. In addition, at least one of the previous TINs received by the driver had to be for a three point speeding offence or two one point speeding offences (that is, for exceeding the speed limit by less than 10 km/h). Young drivers were excluded because drivers with a probationary licence have a lower (5 point) demerit point limit and would therefore have already been subject to intervention prior to the demerit point threshold used in this study. Other eligibility criteria were employed to exclude very high risk drivers and to limit the sample to those who had access to a standard vehicle that they would drive during the study period and who lived close enough to Melbourne to have the system installed. The specific criteria were:

- aged over 21
- have no previous or current licence suspensions/cancellations/disqualifications
- never reached >=12 demerit points or received an Option Notice before or during the trial
- no criminal convictions or pending charges
- reside within 150km of the Melbourne CBD
- be available in Victoria during the trial to complete the required activities
- own or have access to a Victorian registered vehicle
- drive a standard vehicle (excludes taxis, fleet vehicles, motorcycles, vehicles over 4 tonnes)
- not plan to be away from home for an extended period of time during the trial
- drive their vehicle for at least 2000 km over the 20 week duration of the study
- agree to disable any non-trial ISA device or GPS (satellite navigation) system in their vehicle during the trial

Participants who successfully completed the ISA trial received a $300 gift card to cover their time and travel expenses. Additionally, half of the participants in each group, chosen at random, had three demerit points removed from their current driver demerit history if they successfully completed all trial requirements.

Design

The trial was designed by VicRoads and comprised four groups that differed in terms of whether or not they had an ISA system fitted and whether or not they had demerit points removed if they successfully completed all trial requirements. Participants were randomly allocated to each group at the time of recruitment. The groups and the number of people recruited in each group are shown in Table 1.

Table 1. Study group characteristics and number of participants recruited in each group

Group	ISA system fitted	Demerit points removed	Number recruited
Speed Alert	Yes	No	26
Speed Alert & Demerit	Yes	Yes	26
Speed Data	No	No	27
Speed Data & Demerit	No	Yes	26

Materials

ISA Device, Data Logger, & Speed Zone Map

The 'SpeedAlert' ISA system (Smart Car Technologies) is an advisory system that warns the driver when travelling over the posted speed limit. The local speed limit is determined by comparing the vehicle's location coordinates (obtained from the GPS) with an on-board speed zone map of the Victorian road network, mapped and provided by VicRoads.

The ISA system had a three-stage warning sequence consisting of visual and auditory alerts. First, when the posted speed limit was exceeded by 1-2 km/h, a visual speed limit icon denoting the posted limit filled with red. This visual warning remained in place until vehicle speed was reduced below the stage one threshold. In the second warning phase, when vehicle speed reached 2-4 km/h over the speed limit, the driver received a single auditory tone (beep) in addition to the visual icon remaining red. In the third warning stage, when vehicle speed reached more than 4 km/h above the speed limit, the system issued a rapid triple beep auditory warning which continued until the vehicle's speed returned to below the warning threshold. In addition to the speed warnings, the ISA device also issued a soft tone when entering a new speed zone to alert the driver of the speed zone change.

Each vehicle in both the Speed Alert groups and the Speed Data groups was fitted with a data logging system that automatically collected a wide range of data, such as vehicle speed, time, date, location, screen status and alert status. Data were recorded at a rate of 1 Hz and transferred wirelessly over the internet to the Smart Car Technologies monitoring server.

Procedure

Recruitment

The ISA trial ran from October 2010 to June 2012. Victorian drivers who were potentially eligible to take part in the trial were identified by VicRoads using the VicRoads Driver Licensing System (n=6588). Drivers were allocated randomly to the four study groups in the order that they were identified from the Driver Licensing System; that is, the first driver was allocated to group 1, the second driver was allocated to group 2, and so on. Candidates were sent a letter by mail outlining that they had been identified as a potential participant for the RST and that they may receive a phone call inviting them to participate in the trial. The recruitment company (Your Source, a division of Colmar Brunton) attempted to contact 1096 of these drivers by telephone to invite them to take part in the ISA trial and 105 were successfully recruited. The 991 who were not recruited comprised those that refused to participate (n=585), those who failed the introductory screening due

to language barriers or not meeting eligibility criteria (n=20) and those who could not be reached (e.g. answering machine, engaged, no answer after 2 attempts) (n=386).

Once the participant verbally agreed to participate they were provided with details of the trial group to which they were randomly assigned. Participants were sent, by mail, a plain language statement, a participant agreement and a survey to collect data on demographics, driving exposure, personality characteristics, perception of road safety issues and attitudes towards driving. Participants were required to complete the survey and participant agreement and return them to the recruitment provider. Participants were classified as recruited if they returned a signed consent form and a completed pre-intervention survey. Participants were able to withdraw from the trial at any stage (both before and after signing the participant agreement) by doing so in writing.

The ISA trial took approximately 21 weeks for each participant to complete. An overview of the timing of trial activities for individual participants in the ISA trial is contained in Figure 1. Participants in the Speed Alert group had their vehicle fitted with the ISA device and data logging system. The ISA device remained in their vehicle for 12 weeks (the "ISA Active" period), after which it was removed. Within one week of the ISA device being removed, participants completed an interview about their experience with ISA and, four weeks after ISA removal, completed another survey on perception of road safety issues and attitudes towards driving. The data logger remained in the Speed Alert group's vehicles for the entire 20 week trial. The 8 weeks of the trial where only the data logger was present is referred to as the 'After ISA' period. During the entire period that the data logger was fitted, each participant's logged driving data was checked on a weekly basis for any instances of sustained dangerous driving. For the purposes of the RST, two criteria of sustained dangerous driving were developed that were based on those used in the TAC SafeCar project (Regan et al., 2006):

1. 10% or more of the time spent driving 15km/h over the speed limit on two or more days during a week
2. Exceeding the posted speed limit for at least 15 seconds by 25 km/h or more on three or more occasions during a week.

If participants were found to meet either criterion for sustained dangerous driving they were disqualified from the trial as a duty of care requirement. Participants were aware of these criteria prior to consenting to the trial.

The Speed Data group had their own vehicles fitted with the data logging device only, which remained in place for 20 weeks. For the purposes of comparing this group with the Speed Alert group in the analyses, the Speed Data groups' trial was split into the equivalent 12 week 'ISA Active' period and an 8 week 'After ISA' period. Approximately 16 weeks after installation of the data logger, the Speed Data participants also completed a second survey.

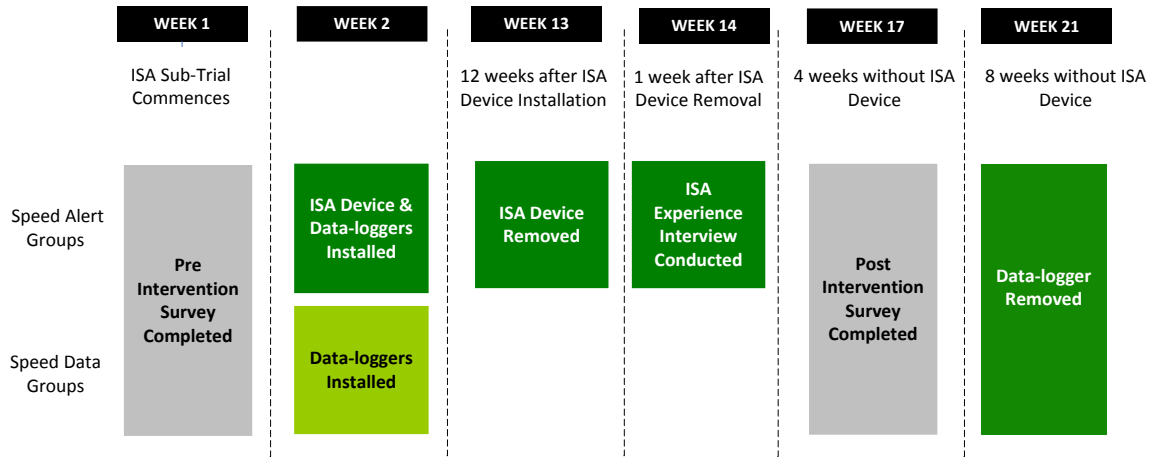

Figure 1. ISA trial activities and timelines for the Speed Alert and Speed Data participants

Data preparation and analysis

Vehicle speed data were filtered to exclude observations where the vehicles were travelling slower than 20 km/h or faster than 30 km/h above the speed limit. This ensured that speed was not constrained by slowing or stopping for traffic congestion, traffic control devices such as traffic lights or to make turns and that the data were less likely to contain observations where the ISA device map contained an incorrect speed limit. The proportion of data excluded through filtering was relatively small and did not differ across the four groups. Filtering was also conducted to include only data that were collected in 40 km/h, 50 km/h, 60 km/h, 70 km/h, 80 km/h and 100 km/h speed zones. Only data that met strict criteria for reliability of the GPS signal and the ISA map were included. More than three satellites had to be visible and horizontal accuracy had to be high (Horizontal Dilution of Precision less than four). Documented cases where the ISA speed map was inaccurate were removed from the data set.

Analyses were performed using Generalised Estimating Equations (GEE) to determine if there were significant differences in mean speed, proportion of time above the speed limit, and the time to return to the speed limit after a warning across the four groups, trial periods and speed zones. GEEs are used to analyse correlated data from longitudinal and repeated-measures trials, which is applicable for data from this trial as there is a correlation between the speed behaviour of the same participant taken over time and also across different speed zones. Essentially the GEE models sought to establish if 1) the use of ISA improved speed behaviour significantly, 2) if demerit point removal had any additional impact on behaviour, 3) if any benefits of ISA remained after it was removed, and 4) if ISA was more effective in certain speed zones.

Results

105 participants were recruited and 86 successfully completed the trial (refer to Table 2.). There was no evidence of selection bias or randomisation bias. There was no significant difference in age between the recruited drivers and the pool of 6588 eligible drivers. There was no significant difference in age, sex or driving experience between those 105 drivers who were recruited and those 991 that were not, nor between the four study groups, nor between those who dropped out and those that completed the trial. Drop-out rate was not related to whether or not the participants experienced ISA or not, however, the drop-out rate was higher for participants who did not have demerit points removed (Fisher's exact test, p=0.04). Given that participants dropped out of the trial for various reasons (including being disqualified for dangerous driving), it is difficult to know the extent to which the lack of demerit point removal contributed to the relatively higher drop-out rate.

Table 2. Number of participants in each group by completion status and sex

Group	Number recruited	Number (%) who completed trial	Number (%) who did not complete trial[#]
Speed Alert	26 (11F, 15M)	17 (65.4) (8F, 9M)	9 (34.6) (3F, 6M)
Speed Alert & Demerit	26 (14F, 12M)	23 (88.5) (13F, 10M)	3 (11.5) (1F, 2M)
Speed Data	27 (18F, 9M)	22 (81.5) (14F, 8M)	5 (18.5) (4F, 1M)
Speed Data & Demerit	26 (13F, 13M)	24 (92.3) (12F, 12M)	2 (7.7) (1F, 1M)

Includes participants who withdrew or were disqualified from trial or who did not complete a full set of logged driving data

Mean Speed

The mean speed of each participant's vehicle during each period was calculated controlling for differential exposure to various speed limits by each participant. Figure 2 displays the mean speed for each group during each period. There was a significant two-way interactive effect of period and ISA group on mean speed (p=0.003), but the three-way interactions between ISA group, period and speed limit (p=0.28) and ISA group, period and demerit point group (p=0.15) were not statistically significant. This indicates that the change in mean speed over time for the Speed Alert (ISA) group differed to the Speed Data (No ISA) group, but that this change was not moderated by demerit point removal or speed limit. There was also no main effect of demerit point removal on mean speed (p=0.59).

The Speed Alert (ISA) group had a significantly lower mean speed than the Speed Data (No ISA) group during the period when the ISA was active (-1.22 km/h, 95%CI -2.04 to -0.39, p=0.004), however there was no significant difference between the Speed Alert group and the Speed Data group in the After ISA period (-0.59 km/h, 95%CI -1.45 to 0.27, p=0.18).

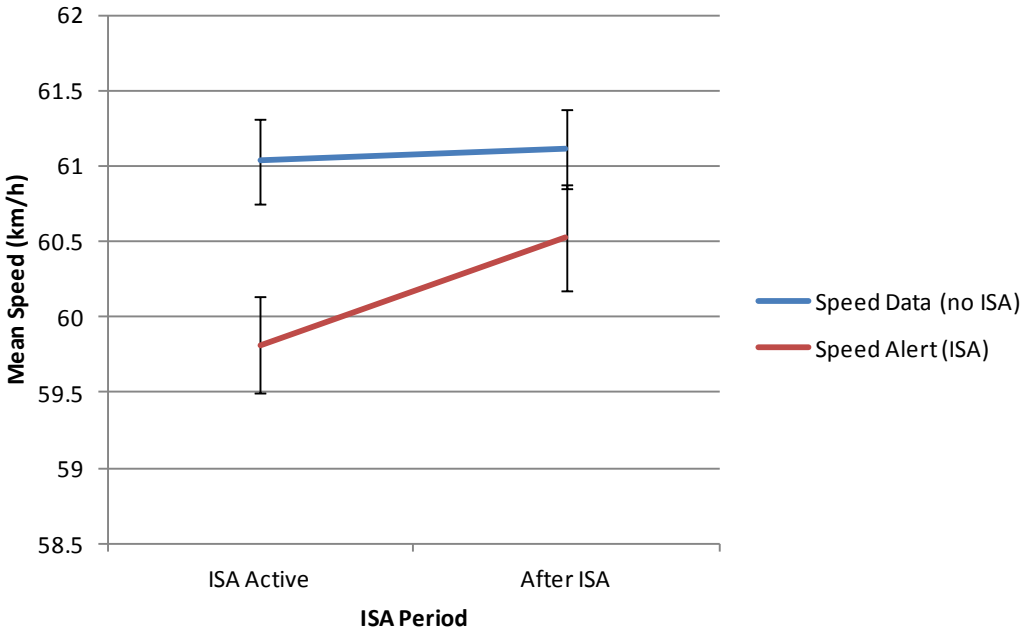

Figure 2. Mean speed (standard error) for each ISA Group during each period

Proportion of time exceeding the speed limit

The proportion of driving time spent exceeding the posted speed limit was calculated, again controlling for differential exposure to various speed limits by each participant, and is displayed in Figure 3 for each group during the two time periods. There was a significant period by ISA group interaction ($p<0.005$), thus the change over time in the proportion of time spent speeding differed by ISA group. There was no three-way interaction with speed limit ($p=0.59$) or demerit point removal ($p=0.15$) which indicates that demerit point removal did not moderate the effect of ISA on the proportion of time spent speeding, and that ISA effectiveness did not differ by speed limit. There was also no significant main effect of demerit point removal on the proportion of time spent speeding ($p=0.56$).

Further investigation revealed that the Speed Alert (ISA) group spent a significantly lower proportion of time speeding (almost 40% less, refer to Figure 3) when ISA was active (9.4%) than the Speed Data (no ISA) group (15.6%) did during the same period (OR=0.53, 95%CI 0.37-0.77, $p=0.001$).In the period when ISA was inactive (After ISA) there was no significant difference between groups in the proportion of time spent speeding (14.4% versus 16.6%; OR=0.86, 95%CI 0.61-1.20, $p=0.38$).

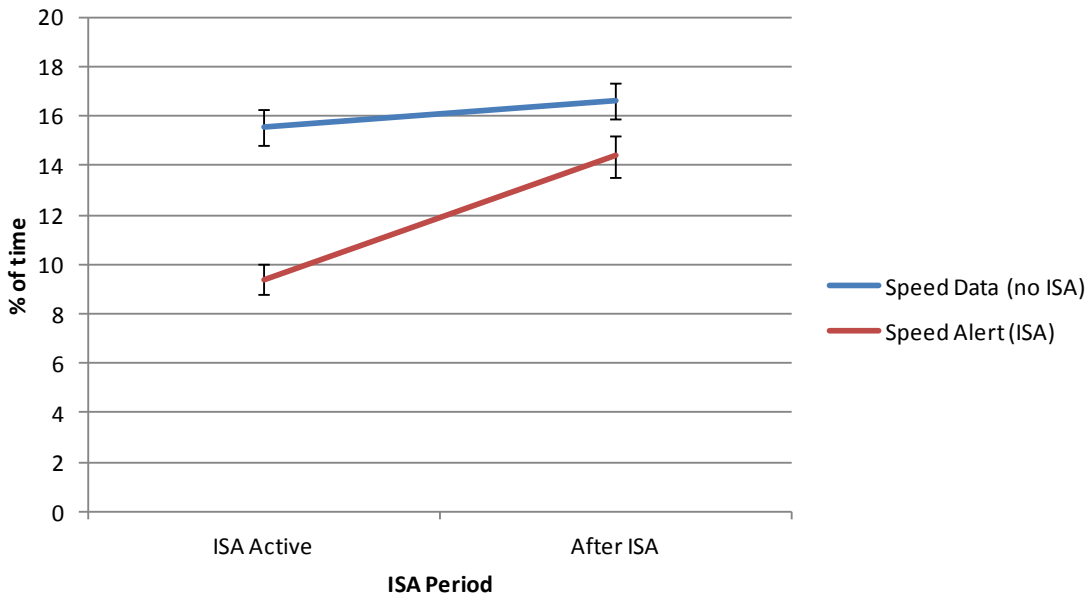

Figure 3. Mean (standard error) proportion of time spent travelling over the speed limit for each ISA group during each period

Time to return to speed limit

The mean time (seconds) taken to return to the speed limit after it was exceeded and an ISA warning was issued was examined across the four ISA groups, ISA periods and speed zones. A significant ISA group by period interaction was found ($p<0.005$). Figure 4 shows the mean time to return to the speed limit for the Speed Alert (ISA) and Speed Data (No ISA) groups for both time periods. When the ISA was active, the Speed Alert (ISA) group returned to the speed limit significantly faster than the Speed Data (No ISA) group (-4.61 seconds, 95%CI -5.91 to -3.31,

p<0.005), however, there was no significant difference between the groups in the After ISA period (-0.67seconds, 95%CI -2.14 to 0.79, p=0.37).

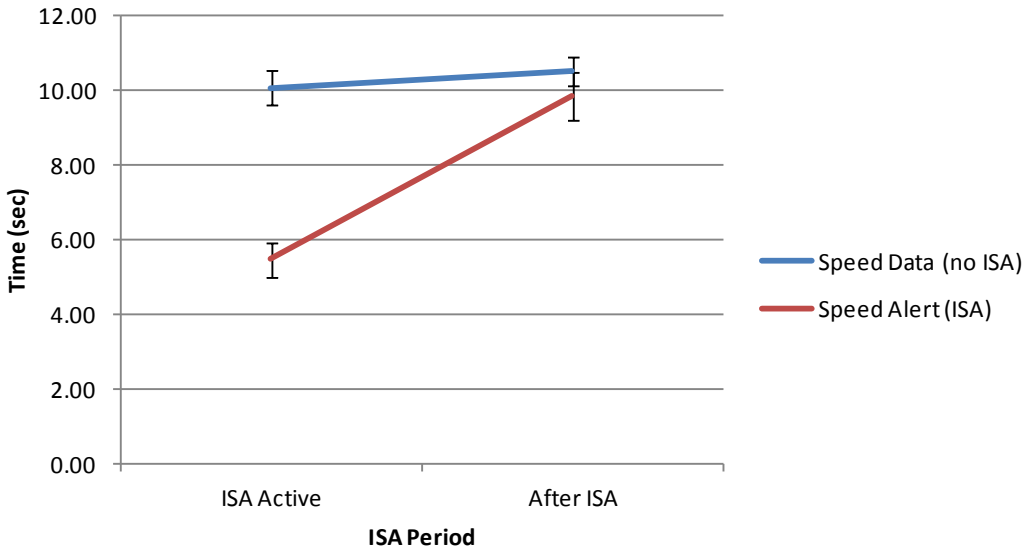

Figure 4. Mean (standard error) time to return to the speed limit for each ISA group during each period

Demerit point removal did not impact on the effectiveness of ISA (p=0.74 for three-way interaction between ISA group, period and demerit point removal), nor was there a main effect of demerit point removal (p=0.27). There was, however, a significant three-way interaction between ISA group, period and speed limit (p=0.025), indicating that the effect of ISA on the time to return to the speed limit differed according to speed zone. Figure 5 shows that the greatest relative improvement in the time taken to return to the speed limit when ISA was active was in 100 km/h zones.

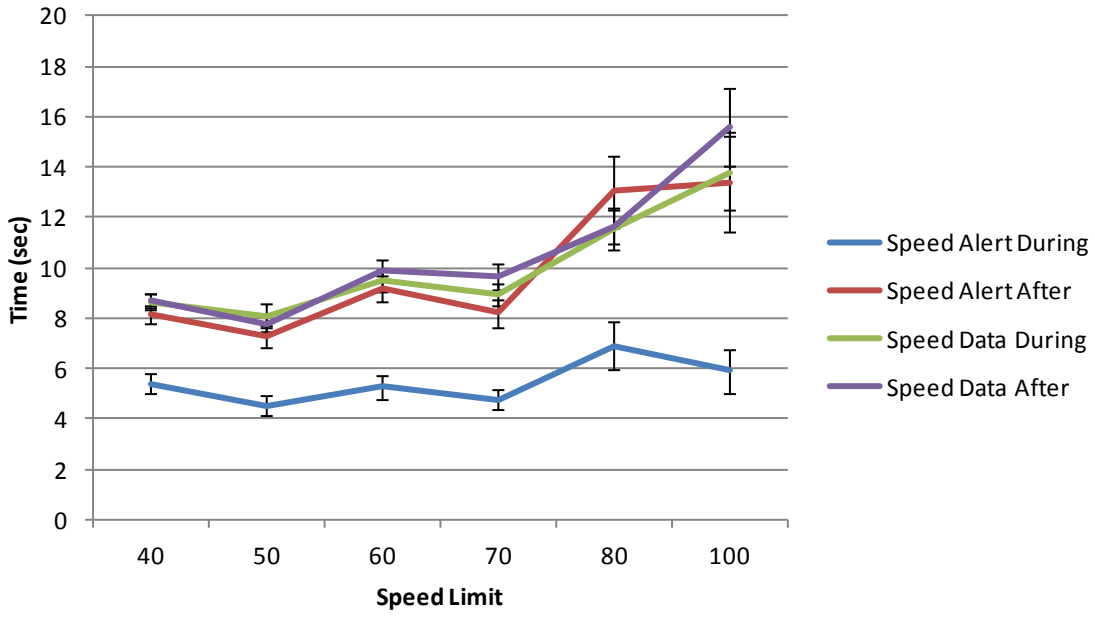

Figure 5. Mean (standard error) time to return to the speed limit for each ISA group during each period, over speed zone

Discussion

The ISA trial aimed to evaluate the effectiveness of an advisory ISA system, either coupled with demerit point removal or not, in reducing recidivist speeders' speeding behaviour. The effectiveness of the ISA system in changing driver speed behaviour was evaluated using a range of speed measures, including mean speed, proportion of time spent over the limit and the time it took the driver to return to the speed limit after receiving a warning.

The use of an advisory ISA system in this sample of recidivist speeding drivers significantly reduced mean travel speeds (by an average of 1.22 km/h across speed zones), the proportion of time spent speeding (by an average of 40%) and the time it took drivers to return to the speed limit (by an average of 4.6 seconds) compared to a group of drivers who did not have an ISA system. Although the mean speed reductions appear small, small speed reductions are associated with crash reduction benefits (e.g. Nilsson, 2004) and the reduction in the proportion of speeding drivers was substantial. These results are similar to those found in the Netherlands study of serious speeders (van der Pas, Kessels, Veroude et al., 2014; van der Pas, Kessels, Vlassenroot et al., 2014) and other studies of ISA in passenger car drivers who were not recidivist speeders (Adell et al., 2008; NSW Centre for Road Safety, 2010; Sundberg, 2001). In most cases, the ISA system was equally effective across different speed zones, with the time to return to the speed limit being the one exception. While the time to return to the speed limit was significantly shorter in all speed zones for drivers with the active ISA system than drivers with no ISA, the greatest relative improvement was in 100 km/h zones.

A clear finding from the current study is that the speed reducing effects of ISA do not remain once the device has been removed from the vehicle. That is, for the eight weeks after the ISA device was removed, speeding behaviour increased and was no longer significantly different from the drivers who had not had an advisory ISA device. The finding that the positive speed reduction effects of ISA did not persist after the ISA system had been deactivated has been observed in a number of other ISA trials, including the Netherlands study of serious speeders (e.g. van der Pas, Kessels, Veroude et al., 2014; van der Pas, Kessels, Vlassenroot et al., 2014; Adell et al., 2008; Regan et al., 2006; Wallén Warner & Aberg, 2008). Such findings indicate that ISA affects speed changes by means of tactical and operational feedback to support the driver to regulate his/her speed behaviour, rather than by longer-term self-regulation in the absence of speed alerting feedback. The findings also suggest that ISA systems need to remain active in order to confer their safety benefits, although to the authors knowledge there have been no long term studies where drivers used ISA for a very long period, the ISA was removed and subsequent speed behaviour was measured.

While ISA was found to be effective, there was insufficient evidence for benefits arising from the prospect of demerit point removal upon completion of the trial. The addition of demerit point removal did not appear to further improve speed behaviour over and above that of the ISA system for any of the measures examined. Nor did it lead to worse speeding behaviour. Furthermore, it is worth noting that the impact of the actual removal of demerit points upon subsequent risky driving behaviour is not addressed by this study and at present is unknown. Overall, the results in this study suggest that ISA alone is sufficient to bring about positive changes in repeat speeders' speed choices, potentially because of the immediacy of the feedback.

There were some limitations observed with the device. First, it did not work in tunnels or under significant cover (e.g. built-up areas) due to the inability to receive an accurate GPS location or problems discriminating between overlapping roads. Secondly, the Speed Zone Map was not 100% accurate; meaning that the devices may have displayed the incorrect limit for a road or may not always have detected a change in the speed limit. This issue was partly addressed by having a feedback mechanism where participants could call a project hotline to log discrepancies. Participants in the Speed Alert group were also given the opportunity to provide information about inaccuracies with the speed map during their interview. Map updates were then periodically provided automatically over the internet. Third, the device had limitations common to all GPS

devices. The device could sometimes take a long time to boot and the signal could stray to the wrong roads. For example, the device could have difficulty distinguishing between two roads running closely in parallel. These issues, however, are unlikely to affect the estimates of ISA effectiveness reported in this paper.

The design of the RST meant that baseline (pre-ISA) speed data were not collected. Rather, conclusions regarding ISA effectiveness were made by comparing the treatment and control groups' speeds during and after the treatment group's exposure to ISA. Baseline data were not collected because participants for the RST were recruited immediately after they received a TIN for speeding (the trigger TIN). This meant that any baseline (pre-ISA) data collected may have been affected by the receipt of the TIN and, thus, would not be a true reflection of participants' baseline speeding behaviour. The inclusion of the control group, however, enabled estimation of the relative reduction in speeding due to ISA because the random assignment of participants to groups meant that there was no reason to suspect that the speeding behaviour of the control group who did not receive ISA differed systematically to the pre-ISA baseline driving behaviour of the group that did experience ISA. Furthermore, the effect of ISA on speeding behaviour of this sample of drivers was very similar to the effect of ISA found for other passenger car drivers in previous research, including the Netherlands study of serious speeders (van der Pas, Kessels, Veroude et al., 2014; van der Pas, Kessels, Vlassenroot et al., 2014).

The results of this study may not be generalisable to the greater population of repeat speeders if the trial suffered from selection bias (i.e., if the sample of drivers that participated in the trial were different to the population of repeat speeders). In the Netherlands study of serious speeders (van der Pas, Kessels, Veroude et al., 2014; van der Pas, Kessels, Vlassenroot et al., 2014), serious speeders were recruited after responding to advertisements. Drivers (volunteers) who respond to advertisements are unlikely to be representative of all serious speeders. For example, young drivers were under-represented in the Dutch study. Our sample of repeat speeders, however, was recruited from the population of all Victorian repeat speeders who were identified from infringement records. All repeat speeders had an equal chance of being contacted for participation and we found no difference in age, sex or driving experience between those who were recruited and those that were not. While it is possible that the drivers in our study may differ from the population of repeat speeders in other (unmeasured) ways, the comparability of our sample and the population of repeat speeders in terms of two of the most important risk factors for speeding (sex and age) is reassuring.

Conclusions

Advisory ISA was found to be effective in reducing speeding behaviour in a sample of Victorian recidivist speeders. These results are especially promising given that this is the only the second study known to the authors to demonstrate the effectiveness of ISA in drivers with a history of speeding. If implemented as part of an intervention for repeat speeders, it is recommended that ISA would need to remain in the vehicle as evidence to date indicates it does not change driver speeding behaviour long-term.

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