Article:
Rowe, R., Maurice-Smith, M., Mahmood, M. et al. (2021) Understanding intentions to override intelligent speed assistance prior to widespread availability: An application of the theory of planned behaviour. Accident Analysis & Prevention, 151. 105975. ISSN: 0001-4575

https://doi.org/10.1016/j.aap.2021.105975

22 December 2020

Understanding intentions to override Intelligent Speed Assistance prior to widespread availability: An application of the Theory of Planned Behaviour

Richard Rowe, PhD, Martha Maurice-Smith, BSc, Myra Mahmood, BSc, Alishba Shuja, BSc & Daisie Gibson, BSc

Department of Psychology, University of Sheffield, UK

Address correspondence to: Professor Richard Rowe, Department of Psychology, University of Sheffield, 1 Vicar Lane, Sheffield S1 2LT. Tel: (+44) (0)114 22 26606.

Email: r.rowe@sheffield.ac.uk

Abstract

Intelligent Speed Assistance (ISA) offers a technological solution to reduce speeding that will become more common in vehicles in the short to medium term. Many implementations allow drivers to override the system's speed control and minimising such interventions can optimise safety benefits. This paper aims to inform behaviour change interventions to reduce ISA overriding targeted to drivers as they obtain vehicles fitted with ISA. We explore the beliefs underlying intentions to override ISA to exceed the speed limit in drivers with limited ISA experience using the Theory of Planned Behaviour. In a sample of 121 drivers (mean age 36 years), regression modelling showed that attitudes strongly predicted intentions with an additional contribution from subjective norms but not perceived behavioural control. Behavioural beliefs underlying attitudes addressed overriding ISA for (1) responsibly controlling the car to minimise crash risk and (2) reducing journey times and enjoying fast driving. Salient normative beliefs focussed on groups that would disapprove of overriding ISA including emergency services and parents. We discuss how these beliefs might be addressed in interventions to maximise the safe adoption of ISA.

Introduction

Road traffic crash (RTC) is the world's eighth most common cause of death overall, with more than 1.35M fatalities annually (World Health Organisation, 2018). Speeding increases the chances of crash involvement and crashes at higher speed have more serious consequences (Aarts & van Schagen, 2006). As such speeding makes a strong contribution to the RTC public health burden. For example, during 2017 in the US, speeding (including driving too fast for conditions) was implicated in 9,717 RTC fatalities; 26% of the total (National Centre for Statistics and Analysis, 2019). Identifying methods to maintain safe driving speeds remains a challenge for researchers and policy-makers. Behaviour change interventions are plausible tools, and some promising approaches have been demonstrated, for example as based on the Theory of Planned Behaviour (TPB; Elliott & Armitage, 2009), but the overall public health impact of road safety education seems limited at best (Ker et al., 2003). Speeding can be reduced via enforcement, for example through speed cameras (Wilson, Willis, Hendrikz, Le Brocque, & Bellamy, 2010). The introduction of enforcement must pass the test of public acceptability. It has been argued that an important but usually unevaluated aspect of road safety education may be to increase the perceived legitimacy of enforcement, therefore indirectly making behaviour safer through facilitating more effective enforcement approaches (McKenna, 2010).

Advances in automobile technology offer alternative methods to control driving speed. Full automation could remove the possibility of speeding altogether, although this may itself present challenges to the acceptability of the technology. However, full automation even in high income countries is a long-term goal. Other forms of assistive technology can help to reduce speeding and therefore RTCs in the interim. Intelligent Speed Adaptation, or more recently Intelligent Speed Assistance (ISA), refers to a range of in-car devices that can support safe driving speeds. This technology can involve providing a warning or directly intervene in car control when the speed limit is exceeded, for example by cutting fuel transmission to the engine until vehicle speed returns to the speed limit. ISA devices have

been widely trialled across high income countries during this century, with the general finding that they can substantially reduce speeding behaviour (Carsten, 2012). For example, Lai, Carsten, and Tate (2012) showed that requiring ISA could reduce serious road traffic injuries by up to 30%, with the extent of the benefit depending upon how strictly ISA control is adhered to.

Many ISA systems that intervene to reduce vehicle speed provide an override option, for example through the driver pressing hard on the accelerator; the precise format of ISA that is most acceptable to drivers is the subject of current research (Carsten, Ezenwa, Tomlison, & Horrobin, 2020). This allows drivers to choose to exceed the speed limit at their discretion. The design intention may be to allow occasional overriding in emergency situations, for example when overtaking on a single lane road and facing an unanticipated oncoming vehicle. However, Lai and Carsten (2012) showed that, while their intervening ISA system reduced vehicle speed in a 6 month 'A-B-A' field trial design, drivers chose to override quite frequently; on 16% of distance travelled in 70 mile per hour (mph) roads, 13% in 20 mph limits and 7-8% on 30, 40 and 50 mph roads. Overriding was most common in young and male drivers for whom speed control might be most beneficial for safety, given that more frequent road safety violations are reported in these groups (de Winter & Dodou, 2010).

ISA systems are likely to become more common in many high income countries in the near future. For example, the European Union will make an overridable ISA mandatory in new vehicles, with legislation coming into force from 2022 (European Transport Safety Council, 2020). If ISA is routinely overridden then the potential road safety benefits of such legislation will not be fully realised. Road safety campaigns encouraging drivers not to override ISA have a potential role here. Firstly, they can encourage drivers to change their overriding behaviour. While the evidence is that educational interventions do not have large effects on road safety behaviour, as noted above, the introduction of ISA provides a new context in which to present behaviour change interventions that could make them more powerful. This potential is demonstrated by Chorlton and Conner (2012) who found that

engaging in an ISA field trial had a carry-over effect on weakening intentions to speed beyond the end of the trial. Second, behaviour change intervention may also increase the perceived legitimacy of future legislation that might increase ISA compliance by requiring fitted ISA systems to become more difficult to override.

The point of technology adoption may be a key stage for intervention. Lahrmann, Agerholm, Tradisauskas, Næss, et al. (2012) reported difficulties in recruiting a sample for an incentivised ISA trial, highlighting that drivers may be initially sceptical about engaging with the technology. Therefore, behaviour change activity aimed at current non-ISA users to encourage them not to override ISA once they purchase cars fitted with ISA may be particularly valuable. To inform such behaviour change activity, it is crucial to understand beliefs and intentions about using ISA in drivers that do not currently have access to ISA.

The TPB (Azjen, 1991) provides a useful basis on which to structure effective health behavioural interventions (Webb, Joseph, Yardley, & Michie, 2010). The TPB models intention to perform a behaviour (e.g., overriding ISA while driving) as the most proximal predictor of that behaviour. Intention is modelled to depend upon three psychological constructs; (a) attitudes, which represent positive/negative evaluations of the behaviour, are in turn modelled to be predicted by a set of behavioural beliefs. Relevant beliefs here might be that overriding ISA would facilitate short journey times (leading to positive attitude towards the behaviour), or that overriding the ISA would increase crash risk (leading to more negative attitude). (b) Subjective norms, which represent perceived social norms regarding the behaviour, are modelled to be predicted by underlying normative beliefs regarding the views of significant others on whether ISA should be overridden. (c) Perceived behavioural control, which represents opinion on how easy/difficult it is to control the behaviour, is modelled to be based on control beliefs regarding factors that facilitate/inhibit performing the behaviour in question. Application of the TPB to intervention design involves identifying the key behavioural, normative and control beliefs that underlie intentions. Interventions can then strengthen beliefs underlying safe behaviour and challenge beliefs that promote unsafe behaviour (Azjen, 2011).

The TPB has usefully modelled the psychological processes underlying intentions to speed and related risky driving violations in a number of studies (Chorlton, Conner, & Jamson, 2012; Parker, Manstead, Stradling, Reason, & Baxter, 1992; Rowe et al., 2016) and has formed the basis of effective interventions, as described below. Therefore, the TPB might be expected to be useful in understanding and influencing ISA use as well. In general, these studies support independent roles for attitudes, subject norms and perceived behavioural control in understanding speeding intentions with minor variations in which component was most strongly associated. For example, Rowe et al. (2016) found that attitudes were the most strongly related to speeding intentions whereas Parker, Manstead, Stradling, Reason, et al. (1992) found that PBC was most strongly related. A number of studies have identified salient beliefs underlying the TPB components (e.g., Elliott, Armitage, & Baughan, 2005; Parker, Manstead, Stradling, & Reason, 1992; Rowe et al., 2016). For example, Rowe et al. (2016) identified behavioural beliefs that counter speeding including increased risk of crash and citation whereas supporting beliefs included looking good and shorter journey times. Important normative beliefs included disapproval of speeding by the authorities and family members whereas control beliefs that inhibited speeding included weather conditions, passengers and the presence of police enforcement. The TPB has provided the basis for effective interventions to improve road safety behaviour (Elliott & Armitage, 2009; Parker, Stradling, & Manstead, 1996). For example, Elliott and Armitage (2009) found presenting messages addressing the beliefs underlying the components of the TPB reduced self-reported speeding. This effect was mediated by changing salient control beliefs that in turn influenced perceived behavioural control over speeding.

With the intention to inform interventions to reduce the amount that drivers override their ISA, this study tests how the components of the TPB relate to intention to override and identifies the salient underlying behavioural, normative and control beliefs. First, drivers identified potential beliefs that may underlie intention to override ISA in a qualitative study. In order to understand which identified beliefs would be most usefully targeted in intervention we conducted an online survey and quantitatively tested the extent to which the most

commonly identified beliefs were associated with components of the TPB, and which TPB components were most strongly associated with intentions to override ISA. The sample was predominantly comprised of drivers that did not currently have vehicles with ISA fitted, reflecting the contemporary UK driving community.

Method

Elicitation study

A convenience sample of 22 participants took part in our qualitative belief elicitation study (Azjen, 2011) in autumn 2019. The inclusion criteria were being at least 18 years old and holding a full UK driving licence. The sample was 64% male and 36% female, with mean age 31 years (SD=13.56, range 18 – 60) and 45% reported their ethnic origin as White, 41% Pakistani and 14% other ethnic origin. More than half (54.54%) had been driving for 5 years or more. Participants gave informed consent and the elicitation study was approved by the Research Ethics Committee of the Department of Psychology at the University of Sheffield.

Participants completed a paper questionnaire that described the ISA system that is planned for implementation in the EU (Appendix A). Beyond the presented information, participants may have already been familiar with plans to implement ISA in new UK cars from 2022 as this had been covered in the national press during 2019 (e.g., Topham, 2019). Participants' behavioural beliefs were measured by asking for (a) *advantages*, (b) *disadvantages,* (c) What they would *like* or *enjoy* and (d) *dislike* or *hate* about overriding ISA to exceed the speed limit. Normative beliefs were elicited by asking which individuals or groups of people would (e) *approve*, (f) *disapprove* and (g) if there were any other individuals or groups of people who would *approve* or *disapprove* of them overriding the ISA. Control beliefs were elicited by asking what things would make them (h) *more likely*, (i) *less likely* and (j) other reasons to make them *more or less likely* to override the ISA.

Table 1 shows the coding framework identifying the range of beliefs elicited which was agreed by all authors following an initial reading of the responses. Using this coding

framework, MMS, AS, MM and DG independently coded the presence/absence of each beliefs in the participants' responses. For 81% of beliefs all four investigators agreed on the presence/absence of belief. In 16% of cases three investigators agreed, and the majority view was followed in coding presence or absence. In 3% agreement was split evenly between the 4 raters and beliefs were coded as present in these cases. Table 1 shows the frequency that each identified belief was mentioned.

Table 1. The frequency with which behavioural, normative and control beliefs were identified during the elicitation study.

Belief	Frequency
Behavioural	
Disagree with the speed limit*	1
To look cool*	1
To overtake slow drivers	4
Issues with the ISA tech	6
Wanting to drive fast	6
Getting fined	9
Being in a rush	9
Thinking the system is pointless	9
In an emergency	10
Control of the vehicle	12
Avoid accidents	13
Risk of creating an accident	15
Normative	
Other people overriding the ISA*	1
Cyclists*	1
Women*	1
Law abiding citizens*	2
Driving Instructors*	2
Commuters*	2
Friends*	2
Insurance companies	4
Inexperienced drivers	4
Pedestrians	4
Joyriders	5
Parents	8
Young drivers	12
Emergency services	15
Vulnerable people (e.g., the Elderly)	15
Control	
Smooth driving*	1
Mood*	2
Passengers*	3

School zones	4
Weather	4
Financial incentive/insurance	4
Clear roads + traffic	7
Speed cameras	10
Running late	14
Emergencies (e.g., medical)	15

*Beliefs endorsed less than 4 times were not included in the beliefs questions in the full study.

Main Study

Participants and Procedure

Participants were required to be at least 18 years of age, to hold a full UK driving licence and to complete an online questionnaire. Full data on the measures described below was provided by 121 participants (after 3 missing values were replaced with scale means) who were recruited via email invitation from the University of Sheffield volunteers list that is made up of staff and students during autumn 2019. The sample was 63% female with mean age 35.90 years (SD =15.58, range = 18-76), 74% identified as White British and reported driving for an average of 15.86 years (SD = 14.56, range 0-59). Only 6 participants (5%) reported regularly driving a car with any sort of ISA device fitted. Participants provided informed consent and study procedures were approved by the Research Ethics Committee of the Department of Psychology, University of Sheffield.

Measures

Beliefs measured in the main study were based on the beliefs identified by four or more participants in the elicitation study as shown in Table 1. Participants rated how likely they thought ten statements (listed in Table 2) representing the behavioural beliefs (e.g., Overriding the ISA to exceed the speed limit would *allow me to overtake slow drivers*) were to be true on a 7 point scale anchored Unlikely - Likely. Eight normative beliefs (listed in Table 3) were presented as statements about different groups of people that might approve or disapprove of overriding ISA (e.g., *Vulnerable people (e.g. the elderly)* think that I should/should not override the ISA to exceed the speed limit) on a 7 point scale anchored

Think I should – Think I should not. Seven control beliefs (listed in Table 4) were presented as statements about how situations might affect the likelihood of overriding ISA (e.g., *Being in an emergency situation* would make my overriding the ISA to exceed the speed limit…). Participants rated these on a seven point scale anchored Less likely – More likely.

Attitudes were measured as the mean of four semantic differential items that asked whether overriding ISA would be (1) Pleasant – Unpleasant, (2) Beneficial-Harmful, (3) Enjoyable – Unenjoyable, and (4) Wise – Foolish. Items were rated on 7-point scales, recoded so that high scores implied more positive attitudes towards overriding ISA. Cronbach's alpha reliability was .78 in this sample.

Subjective Norms regarding overriding ISA were measured as the mean of two items, rated on 7-point scales; (1) People who are important to me think I should/should not… and (2) People who are important to me would approve/disapprove of me.... These items recoded so that high scores indicated greater approval of overriding ISA and the scale demonstrated alpha reliability of .75.

Perceived Behavioural Control regarding overriding ISA was measured as the mean of four items; (1) How much control would you have over whether or not you would…? (Complete control – No control), (2) I would have complete control over whether or not… (Agree – Disagree), (3) If I wanted to, overriding the ISA to exceed the speed limit would be… (Easy – Difficult) and (4) If I wanted to, I could easily override the ISA to exceed the speed limit (Likely – Unlikely). Alpha reliability was .82.

Intention to override ISA was measured as the mean of three items; (1) How likely is it that you would…? (Likely – Unlikely) (2) I would be very likely / unlikely to... (Very likely – Very unlikely) and (3) How willing would you be to…? (Very willing – Not at all willing). Items were

recoded so that higher scores indicated stronger intention to override ISA. Alpha reliability was .89.

Analyses

It was expected that the belief measures would be inter-correlated. Therefore, we initially conducted exploratory factor analyses within the behavioural, normative and control beliefs to form correlated beliefs into scales using principal factor analysis in Stata 13 (StataCorp, 2013). We checked that the data were appropriate for factor analysis by assessing whether the Kaiser-Meyer-Olkin (KMO) statistics were above .50 for each set of beliefs. Factors with eigenvalues greater than 1 were retained. Varimax rotation was applied to aid factor interpretation. The items loading onto each factor were analysed using Cronbach Alpha to check internal reliability and were summed to produce scale totals for further analysis.

Ordinary least squares regression was used to (1) identify which behavioural belief factors independently predicted attitudes, (2) which normative belief factors predicted subjective norms, (3) which control belief factors predicted perceived behavioural control with predictors added simultaneously to each model and (4) to assess the relative contributions of attitudes, subjective norms and perceived behavioural control to predicting intention to override ISA. In all cases multiple predictors were entered into models simultaneously.

Results

Exploratory factor analyses of beliefs

Behavioural beliefs demonstrated an adequate KMO statistic of .66, supporting the application of factor analysis. A two factor solution provided a simple structure following varimax rotation, as shown in Table 2. The first factor (Eigenvalue=1.84) contained items regarding responsible overriding of ISA including responding effectively in emergencies and keeping control of the vehicle and formed a reliable scale (alpha = .71) with higher scores more positive about overriding ISA following reverse coding of one item. The second factor

(Eigenvalue=1.59) was made up of items regarding overriding ISA to drive faster including facilitating overtaking and reaching the destination sooner and also formed a reliable scale (alpha=.69), with higher scores more positive about the benefits of overriding ISA in this regard.

Table 2. Varimax rotated factor loadings (>.4) from the behavioural beliefs factor analysis.

Belief	Responsibility factor	Speed factor
Overriding the ISA to exceed the speed limit would…		
…allow me to respond effectively in emergencies.	.69	
…help me to avoid crashes.	.68	
…give me more control over my vehicle.	.58	
…increase my risk of being involved in a road traffic crash.*	-.50	
…allow me to overtake slow drivers.		.64
…help me to reach my destination substantially quicker.		.61
…allow me to enjoy driving fast.		.58
…be more likely because the ISA system allows me to do so with ease.		.49
…be useful when the ISA gets the speed limit wrong.		.41
…increase my risk of getting a speeding fine.**		

*Item reverse coded in scale construction
**Item did not load at .4 or above on either factor

Normative beliefs also demonstrated suitability for factor analysis (KMO=.71). Table 3 shows factor loadings from the 2 factors solution that was supported by inspection of eigenvalues. Social groups who would disapprove of overriding ISA were represented on factor 1 (eigenvalue=2.31) and these items formed a reliable scale (alpha=.78). Factor 2

(eigenvalue=1.04) was made up of two social groups who would approve of overriding the ISA and these two items formed a scale that was reliable (alpha=.72).

Table 3. Varimax rotated factor loadings (>.4) from the normative beliefs factor analysis.

Belief	Disapprovers factor	Approvers factor
… think that I should/should not override the ISA to exceed the speed limit.		
Insurance companies…	.79	
Pedestrians…	.73	
Vulnerable people (e.g., the elderly)…	.68	
My parents…	.59	
The emergency services…	.52	
Young drivers…		.73
Joyriders…		.64
Inexperienced drivers…*		

*Item did not load at .4 or above on either factor

Control beliefs were also suitable for factor analysis (KMO=.67). A 2 factor solution was once again supported by the eigenvalues; rotated factor loadings are displayed in Table 4. These show that the first factor (eigenvalue=1.72) represented situational factors that would inhibit overriding ISA, including road conditions and insurance incentives which formed a reliable scale (alpha=.72). Factor two (eigenvalue=1.12) involved situations that would facilitate overriding ISA, including running late which also formed a reliable scale (alpha=.68). Both scales were naturally scored in the direction that higher scores implied greater likelihood of overriding ISA.

Table 4. Varimax rotated factor loadings (>.4) from the control beliefs factor analysis.

Belief	Inhibitors factor	Facilitators factor

…would make my overriding the ISA to exceed the speed limit less/more likely.		
Hazardous weather conditions…	.72	
Driving in a school zone…	.66	
Speed cameras…	.59	
Financial incentives from my insurance company…	.53	
Being late…		.74
Clear roads…		.71
Being in an emergency situation…		.41

Beliefs underlying Attitude, Subjective Norm and Perceived Behavioural Control

Table 5 shows that stronger behavioural beliefs regarding responsibly overriding ISA and those about overriding ISA to travel faster were independently significant predictors of a more positive attitude towards overriding ISA. Stronger perceived approval for overriding the ISA from groups that would usually be thought of as disapprovers (e.g., insurance companies) was a significant independent predictor of subjective norms. There was no independent contribution of perceptions of approval from groups that might support overriding, such as joyriders. Only the strength of beliefs about situations that might inhibit overriding the ISA predicted perceived behavioural control, there was no independent contribution from strength of beliefs regarding situations that might facilitate.

Table 5. Prediction of attitudes, subjective norms and perceived behavioural control from the belief factors.

Attitude		Subjective norm		Perceived behavioural control	
Behavioural beliefs	Beta (95% CI)	*Normative beliefs*	Beta (95% CI)	*Control beliefs*	Beta (95% CI)
Responsibility	.41* .26, .56	Disapprovers	.41* .24, .57	Inhibitors	.34* .17, .51

Speed	.39* -.24, .54	Approvers	.09 -.07, .26	Facilitators	-.13 -.30, .05
R^2	.35		.17		.12

CI = Confidence Interval *p<.001

Predicting intention to override ISA

Intentions were significantly correlated with attitudes (r=.76, p<.001), subjective norms (r=.49, p<.001) and perceived behavioural control (r=-.28, p=.002). A multiple regression model predicting intention to override ISA from the TPB constructs (R^2=.61) showed that positive attitudes towards overriding ISA was the strongest predictor of intention to override (beta=.67, 95% Confidence Interval (CI): .54, .80, p<.001). Subjective norm also made a significant independent contribution (beta=.16, 95% CI: .03, .29, p=.015). There was no independent contribution from perceived behavioural control (beta=-.06, 95% CI: -.18, .06; p=.323).

Discussion

This study explored the beliefs underlying intention to override ISA in a sample of UK drivers. This sample reported minimal ISA experience, likely reflecting the experiences of large sections of the current global motoring population. Therefore, the results are well placed to identify the beliefs that could be the focus of safety campaigns targeted to the currently large proportion of motorists, in Europe at least, who are likely to be buying their first cars fitted with ISA in the short to medium term, as the technology becomes more prevalent. The TPB guides identification of key salient beliefs; the 2 stage analysis identifies the relative contribution of attitudes, subjective norms and perceived behavioural control make to intention, and the beliefs that underlie each of those constructs. In combination the TPB constructs accounted for 61% of the variance in intention to override ISA, comparing to a mean of 39% in Armitage and Connor's (2001) meta-analysis of 154 studies testing how well TPB constructs explain variance in intention regarding a range of health behaviours. Attitudes were the strongest predictor of intentions. There was a smaller but significant

329 contribution from subjective norms while perceived behavioural control did not make a
330 significant independent contribution to predicting intentions. This highlights the potential
331 importance of targeting the behavioural beliefs that underlie attitudes in interventions to
332 promote ISA use and also suggests there might be some utility in addressing the normative
333 beliefs underlying subjective norms.

334 We identified two separate behavioural beliefs factors, addressing overriding ISA for
335 (1) responsible purposes to control the car safely and (2) to drive faster. These two factors
336 made approximately equal contributions to the prediction of attitudes, accounting for 35% of
337 the total variance. It is noteworthy that these beliefs form different factors as this supports
338 intervening separately with the two underlying reasons for overriding, rather than focussing
339 on a simple message that overriding is dangerous. Of the two factors, the factor focussed on
340 overriding ISA to drive more safely, may need careful consideration in treatment in
341 interventions. Situations in which overriding ISA (i.e., breaking the speed limit) can reduce
342 the risk of crash are likely to be very rare; the weight of evidence is that breaking the speed
343 limit increases crash risk (Aarts & van Schagen, 2006). However, a driving simulation study
344 indicated that a non-overridable ISA could impair overtaking slow vehicles in certain
345 scenarios (Jamson, Chorlton, & Carsten, 2012). The opportunity to override ISA may also be
346 important in providing confidence in adopting ISA initially. Therefore, initial education might
347 usefully emphasise that situations where overriding ISA for safety benefit are likely to be rare
348 and that exposure to such situations should be minimised, for example by deciding against
349 an overtaking manoeuvre that might involve breaking the speed limit. Further qualitative and
350 quantitative research on how this message should be nuanced may also be useful, involving
351 drivers who are familiar with using ISA.

352 The behavioural beliefs factor regarding overriding ISA to allow fast driving offers a
353 much simpler intervention target; desire to overtake other drivers, reach destinations quicker
354 and enjoy driving fast are similar to the sorts of beliefs identified in other studies addressing
355 beliefs underlying speeding intentions (e.g., Rowe et al., 2016). Interventions to address
356 these beliefs might focus on counter-examples to combat these positions, showing that

357 breaking the speed limit will usually lead to trivial changes in journey time and can lead to a
358 lot of unenjoyable consequences such as crashes and traffic citations, accompanied by the
359 humiliation of damage to the car and embarrassing road-side encounters with police. As
360 noted in the introduction, combating beliefs that are positive to speeding in general may be
361 more effective in the context of ISA. Reminders are one way of increasing the effectiveness
362 of intervention (e.g., Pirolli et al., 2017). Interventions on breaking the speed limit can set up
363 warnings and interventions from ISA as cues for behaviour change plans such as
364 implementation intentions that have been found to be effective is moderating speeding
365 elsewhere (Elliott & Armitage, 2006).

366 Wanting to override ISA when it applies an incorrectly low speed limit loaded onto the
367 factor regarding overriding for the purposes of driving fast. While experience with using ISA
368 might demonstrate ISA accuracy, the perception of potential inaccuracy in those who are
369 unfamiliar with ISA remains important in terms of targeting information to motorists before
370 they purchase their first car fitted with ISA and when they first start to use the system. It is
371 noteworthy that this item loaded onto the driving fast factor rather than the responsible
372 overriding factor, indicating that the belief may be more about an inaccurate ISA causing
373 slower journeys rather than presenting a safety risk.

374 Our results also identified a role for subjective norms in the prediction of intentions to
375 override ISA and that beliefs regarding the perceptions of groups that might disapprove of
376 overriding contributed to this. The role of subjective norms was less prominent than attitudes
377 indicating that addressing normative beliefs should have a lower priority than behavioural
378 beliefs in intervention design. However, inclusion of material bolstering the belief that
379 vulnerable groups such as pedestrians, significant others, such as parents and emergency
380 services all disapprove of overriding ISA may have some additional benefit to intervention
381 effectiveness. Insurance companies were also included here, and the message that
382 insurance companies are supportive of ISA compliance may be best communicated via
383 insurance premium discounts as have been trialled elsewhere (Lahrmann, Agerholm,
384 Tradisauskas, Berthelsen, & Harms, 2012).

Perceived behavioural control was not a significant predictor of intentions to override ISA. The TPB allows perceived behavioural control to directly influence behaviour without mediation via intentions. However, behaviour could not be measured in this study due to the infrequency of ISA access in the population. Perceived behavioural control has been identified as related to intentions to speed elsewhere (e.g., Rowe et al., 2016) and therefore might have been expected to relate to intentions to override ISA in this study. It is possible that the role of situational influences on intention to override ISA cannot be imagined by a population that is inexperienced with ISA.

The results presented here must be considered in the context of a number of limitations. First, it is possible that results would be different if the study were repeated using drivers who were experienced in using ISA. For example, experience with ISA might identify other situational factors that influence ISA overriding, such as traffic density and the speeding behaviour of other drivers. Such findings would be useful in developing interventions to increase ISA usage in experienced ISA users and would also provide the opportunity to test how well ISA intentions predict behaviour. Future studies addressing these issues in populations with ISA experience will be valuable. However, as noted in the introduction, the driving population that is largely inexperienced in using ISA is a crucial one to focus on at this time, as ISA is likely to be introduced to this population in the short- to medium-term. It is therefore important to understand the beliefs underlying their current intentions for using ISA to inform road safety campaigns aiming to promote ISA compliance at the point of entry.

Our sample size was adequate to identify relationships across all participants and therefore provide evidence on the beliefs underlying intention to override ISA across the population. We did not have sufficient power to test whether particular TPB constructs or belief sets varied in importance for specific driver groups. For example, ISA compliance may be particularly important for high risk driver groups, such as young drivers or those high in impulsivity, and the importance of some beliefs may vary in those groups. While such nuanced research might provide an effective basis for interventions targeted to high risk

groups, the findings from the full population presented here should be well-placed to inform road safety campaigns that can usefully be presented to all motorists as ISA is introduced to the full driving community. ISA has the potential to substantially reduce speeding and therefore reduce road traffic crashes. Introducing ISA in the context of evidence-based road safety campaigns maximises the chances of realising that potential.

References

Aarts, L., & van Schagen, I. (2006). Driving Speed and the Risk of Road Crashes: A Review. *Accident Analysis and Prevention, 38*(2), 215-224.

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*, 471-499. doi:10.1348/014466601164939

Azjen, I. (1991). The theory of planned behaviour. *Organizational Behaviour and Human Decision Processes, 50*, 179-211.

Azjen, I. (2011). Behavioral interventions: Design and evaluation guided by the theory of planned behavior. In M. M. Mark, S. I. Donaldson, & B. C. Campbell (Eds.), *Social psychology for program and policy evaluation* (pp. 74-100). New York: Guildford.

Carsten, O. (2012). Is intelligent speed adaptation ready for deployment? *Accident Analysis & Prevention, 48*, 1-3. doi:https://doi.org/10.1016/j.aap.2012.05.012

Carsten, O., Ezenwa, A., Tomlison, A., & Horrobin, A. (2020). *ISA Interface Study*. Retrieved from Institute for Transport Studies, University of Leeds: https://environment.leeds.ac.uk/download/downloads/id/5102/isa_interface_study_accessible.pdf

Chorlton, K., & Conner, M. (2012). Can enforced behaviour change attitudes: Exploring the influence of Intelligent Speed Adaptation. *Accident Analysis and Prevention, 48*, 49-56. doi:10.1016/j.aap.2010.06.007

Chorlton, K., Conner, M., & Jamson, S. (2012). Identifying the psychological determinants of risky riding: An application of an extended Theory of Planned Behaviour. *Accident Analysis and Prevention, 49*, 142-153. doi:10.1016/j.aap.2011.07.003

de Winter, J. C. F., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research, 41*(6), 463-470. doi:10.1016/j.jsr.2010.10.007

Elliott, M. A., & Armitage, C. J. (2006). Effects of implementation intentions on the self-reported frequency of drivers' compliance with speed limits. *Journal of experimental psychology. Applied, 12 2*, 108-117.

Elliott, M. A., & Armitage, C. J. (2009). Promoting drivers' compliance with speed limits: Testing an intervention based on the theory of planned behaviour. *British Journal of Psychology, 100*, 111-132. doi:10.1348/000712608x318626

Elliott, M. A., Armitage, C. J., & Baughan, C. J. (2005). Exploring the beliefs underpinning drivers' intentions to comply with speed limits. *Transportation Research Part F-Traffic Psychology and Behaviour, 8*(6), 459-479.

European Transport Safety Council. (2020). Intelligent Speed Assistance (ISA). Retrieved from https://etsc.eu/intelligent-speed-assistance-isa/

Jamson, S., Chorlton, K., & Carsten, O. (2012). Could Intelligent Speed Adaptation make overtaking unsafe? *Accident Analysis & Prevention, 48*, 29-36. doi:https://doi.org/10.1016/j.aap.2010.11.011

Ker, K., Roberts, I. G., Collier, T., Beyer, F. R., Bunn, F., & Frost, C. (2003). Strong evidence that advanced and remedial driver education does not reduce road traffic crashes or injuries. *Cochrane Database of Systematic Reviews*.

Lahrmann, H., Agerholm, N., Tradisauskas, N., Berthelsen, K. K., & Harms, L. (2012). Pay as You Speed, ISA with incentives for not speeding: Results and interpretation of speed

data. *Accident Analysis & Prevention, 48*, 17-28. doi:https://doi.org/10.1016/j.aap.2011.03.015

Lahrmann, H., Agerholm, N., Tradisauskas, N., Næss, T., Juhl, J., & Harms, L. (2012). Pay as You Speed, ISA with incentives for not speeding: A case of test driver recruitment. *Accident Analysis & Prevention, 48*, 10-16. doi:https://doi.org/10.1016/j.aap.2011.03.014

Lai, F., & Carsten, O. (2012). What benefit does Intelligent Speed Adaptation deliver: A close examination of its effect on vehicle speeds. *Accident Analysis & Prevention, 48*, 4-9. doi:https://doi.org/10.1016/j.aap.2010.01.002

Lai, F., Carsten, O., & Tate, F. (2012). How much benefit does Intelligent Speed Adaptation deliver: An analysis of its potential contribution to safety and environment. *Accident Analysis & Prevention, 48*, 63-72. doi:https://doi.org/10.1016/j.aap.2011.04.011

McKenna, F. P. (2010). *Education in Road Safety: Are we getting it right?* (10/113). Retrieved from https://www.racfoundation.org/wp-content/uploads/2017/11/education-in-road-safety-mckenna-080910-report.pdf

National Centre for Statistics and Analysis. (2019). *Speeding 2017 data* (DOT HS 812 687). Retrieved from Washington, DC: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812687

Parker, D., Manstead, A. S. R., Stradling, S. G., & Reason, J. T. (1992). Determinants of intentions to commit driving violations. *Accident Analysis and Prevention, 24*(2), 117-131. doi:10.1016/0001-4575(92)90028-h

Parker, D., Manstead, A. S. R., Stradling, S. G., Reason, J. T., & Baxter, J. S. (1992). Intention to committ driving violations - An application of the theory of planned behavior. *Journal of Applied Psychology, 77*(1), 94-101. doi:10.1037//0021-9010.77.1.94

Parker, D., Stradling, S. G., & Manstead, A. S. R. (1996). Modifying Beliefs and Attitudes to Exceeding the Speed Limit: An Intervention Study Based on the Theory of Planned Behavior. *Journal of Applied Social Psychology, 26*(1), 1-19. doi:10.1111/j.1559-1816.1996.tb01835.x

Pirolli, P., Mohan, S., Venkatakrishnan, A., Nelson, L., Silva, M., & Springer, A. (2017). Implementation Intention and Reminder Effects on Behavior Change in a Mobile Health System: A Predictive Cognitive Model. *Journal of Medical Internet Research, 19*(11), e397-e397. doi:10.2196/jmir.8217

Rowe, R., Andrews, E., Harris, P. R., Armitage, C. J., McKenna, F. P., & Norman, P. (2016). Identifying beliefs underlying pre-drivers' intentions to take risks: An application of the Theory of Planned Behaviour. *Accident Analysis and Prevention, 89*, 49-56. doi:10.1016/j.aap.2015.12.024

StataCorp. (2013). *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.

Topham, G. (2019). All new UK cars to have speed limiters by 2022 under EU plans. *The Guardian*. Retrieved from https://www.theguardian.com/world/2019/mar/27/all-new-uk-cars-to-have-speed-limiters-by-2022-under-eu-plans

Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the Internet to Promote Health Behavior Change: A Systematic Review and Meta-analysis of the Impact of Theoretical Basis, Use of Behavior Change Techniques, and Mode of Delivery on Efficacy. *Journal of Medical Internet Research, 12*(1), 18. doi:10.2196/jmir.1376

Wilson, C., Willis, C., Hendrikz, J. K., Le Brocque, R., & Bellamy, N. (2010). Speed cameras for the prevention of road traffic injuries and deaths. *Cochrane Database of Systematic Reviews*(10). doi:10.1002/14651858.CD004607.pub3

World Health Organisation. (2018). *Global status report on road safety 2018*. Retrieved from https://www.who.int/publications/i/item/9789241565684

Appendix A – ISA description

Intelligent Speed Assistance (ISA) helps drivers to stay within the speed limit while driving. ISA utilises a camera in the vehicle and a satellite navigation system to assess the current speed limit. If the vehicle exceeds the speed limit the fuel reaching the engine is cut, gently slowing the vehicle until it is travelling within the speed limit. **The driver can override the system by applying additional pressure to the accelerator to make the vehicle exceed the speed limit.**

Please imagine that you drive a car fitted with ISA.