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DOI
10.1016/j.trf.2024.06.010

Publication date
2024

Document Version
Final published version

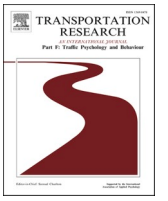
Published in
Transportation Research Part F: Traffic Psychology and Behaviour

Transportation Research Part F: Psychology and Behaviour 104 (2024) 348–358

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf



Perceived effectiveness of traditional and technology-based speeding-related countermeasures

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ARTICLE INFO

Keywords:
Speeding behaviour
Countermeasures
ADAS
Effectiveness

ABSTRACT

Introduction: Speeding behaviour contributes significantly to road crashes and subsequent injuries and fatalities. The purpose of this study was to examine which traditional countermeasures (i.e., police enforcement and on-road signs) and technology-based countermeasures (i.e., advanced driver assistance systems [ADAS] and in-vehicle speed audio alerts) drivers perceived as effective in assisting them to comply with posted speed limits. **Methods:** Participants ($N = 680$; $M_{age} = 49.34$ years) who held a current driver's licence completed a 20-minute online survey. Participants in the experimental condition were randomly assigned to read one of four scenarios which differed based on location (urban or regional) and posted speed limit (60 km/hr or 100 km/hr) or to the control condition (no scenario), before answering questions about the perceived effectiveness of the traditional and technology-based interventions. For the experimental conditions, participants were instructed to respond to these questions based on how they would drive in the situation outlined in the scenario. **Results:** Low-level speeding behaviour was common, with 40.7 % reporting regularly driving 5 km over the posted speed limit in a 60 km/hr speed zone and 50.4 % reporting regularly driving 5 km over the posted speed limit in a 100 km/hr speed zone. A mixed ANOVA revealed that participants perceived police enforcement activities to be the most effective at assisting them to comply with posted speed limits when compared to other traditional and technology-based approaches. Further, ADAS was rated by participants as significantly more effective at assisting them to comply with the posted speed limit in the 100 km/hr urban condition compared to the 60 km/hr urban condition. **Conclusions:** Low-level speeding behaviour remains common practice and there is a need for continued roadside police presence to discourage this behaviour. Drivers with ADAS-equipped vehicles could also be encouraged to use systems, such as adaptative cruise control, to assist with speed management on high-speed roads.

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https://doi.org/10.1016/j.trf.2024.06.010
Received 10 March 2024; Received in revised form 3 June 2024; Accepted 10 June 2024
Available online 16 June 2024

1. Introduction

Each year in Australia, over 1,000 road users are fatality injured and over 39,000 people sustain an injury which requires hospitalisation (Bureau of Infrastructure and Transport Research Economics, 2022). Speeding is one behaviour which contributes to these on-road fatalities and injuries. Speeding can be defined as exceeding the posted speed limit or driving too fast for the given road conditions. Speeding has been reported to increase both crash risk as well as the severity of injuries (Aarts & van Schagen, 2006). While many drivers recognise speeding to be risky, some of them still report engaging in this behaviour (van Souwe et al., 2018). This phenomenon is known as the speed paradox (Fleiter & Watson, 2005), which refers to a mismatch between beliefs and behaviour.

In the last Australian community attitudes to road safety survey found that 27 % of the 1,707 representatively sampled participants reported that it was okay to speed if driving safely (van Souwe et al., 2018). This statistic is consistent with previous Australian community attitudes to road safety surveys conducted between 2005 and 2017. Further, Peterson and Gaugler (2021) found in a sample of US drivers ($N = 309$), that driving up to 10mph (approx. 16 km/h) above the posted speed limit was considered the norm, with some drivers perceiving this behaviour to be low risk. Given that some drivers consider speeding, particularly low-level speeding (i.e., exceeding the posted speed limit by up to 10 km/hr) to be socially acceptable (Job et al., 2013; van Souwe et al., 2018), it is important to investigate drivers' perceptions regarding the effectiveness of speeding-related countermeasures including recent and emerging vehicle technologies which may also assist them to comply with posted speed limit.

1.1. Traditional speeding-related countermeasures

Various countermeasures including police speed enforcement (e.g., speed cameras, police presence) and public education campaigns (e.g., anti-speeding messages) are used to encourage drivers to comply with posted speed limits. Studies which have examined the effect of speed cameras have found some support that sanctions arising from camera detections reduce crashes (e.g., De Pauw et al., 2014; Wilson et al., 2010). For example, Wilson et al. (2010) undertook a review of 35 studies and of those, 28 studies examined the effect of speed cameras on crashes. They reported that these studies found a reduction of crashes in the vicinity of camera sites, with most studies reporting a reduction of between 11–27 % of crashes. Further, De Pauw et al. (2014) reported a significant decrease of severe crashes with serious and fatal injuries at 65 fixed camera sites in Flanders-Belgium. Other research has reported that police presence may also reduce speeding (e.g., Simpson et al., 2020). For example, Simpson et al. (2020) found that even the inanimate presence of a police person (i.e., a realistic-appearing metal cut-out of a police officer) holding a radar device decreased the odds of drivers' speeding on road sites in Canada. A recent study in Australia during the initial COVID-19 restrictions, found that a lack of police presence was associated with more frequent speeding for those who continued to drive during lockdowns (Truelove et al., 2021). Collectively, this research provides support for police speed enforcement activities at reducing drivers' speeding behaviour.

In addition to police speed enforcement, research has found some support for the positive effects of anti-speeding messages displayed on variable message signs ([VMS]; i.e., electronic roadside signs which can be used to display road safety messages) on drivers' attitudes and behaviour (e.g., Glendon & Lewis, 2022; Tay & De Barros, 2010) and crash risk (Megat-Johari et al., 2022). For example, Glendon and Lewis (2022) found that anti-speeding messages displayed on VMS in an urban Australian location with a 60 km/hr speed limit reduced speeding. Specifically, they found that compared to baseline, the percent of vehicles exceeding the posted 60 km/hr speed limit (mean speed) was lower while the message was displayed on the VMS. In contrast, Tay and De Barros (2010) found no difference in mean speed when the message, "speeding, will catch up to you" was displayed on a VMS in Canada. However, they did find a slight reduction in high-end speeds. Megat-Johari et al. (2022) analysed crash data via a series of random parameters negative binomial models and reported that there was a significant reduction in speed-related crashes when safety messages were displayed on VMS between 2014–2018 in Michigan, US.

Other research in this space has also found that the type of message content may also impact drivers' responses towards anti-speeding messages (e.g., Glendon & Cernecca, 2003; Lewis et al., 2017; Tay & De Barros, 2010). For example, Glendon and Cernecca (2003) found that participants were more likely to report that they would reduce speeding after viewing anti-speeding messages which focused on enforcement compared to anti-speeding messages which did not focus on enforcement. However, and as reported above, Tay and De Barros (2010) found no difference in mean speed for a message which focused on the legal threat of speeding behaviour. Further, Lewis et al. (2017) found that in a sample of young Australian males, anti-speeding messages which addressed salient control beliefs were perceived by them to be persuasive. The current study extends upon this previous research by examining the perceived effectiveness of countermeasures, including deterrence-based sanctions and on-road messaging, on self-reported speeding behaviour.

1.2. Emerging vehicle technologies

New vehicles equipped with Advanced Driver Assistance Systems (ADAS) are becoming more common in Australia. These technologies are designed to assist the driver in the operation of the vehicle and increase driver safety. Previous research has provided some initial support for these systems in reducing crashes (e.g., Leslie et al., 2021; Masello et al., 2022). For example, Leslie et al. (2021) reported that automatic emergency braking could reduce rear-end crashes by 38 %. They also found that lane keeping assist with lane departure warning could reduce lane departure crashes by 12 %. Further, Masello et al. (2022) reported that deployment of vehicles with adaptive cruise control, automatic emergency braking, blind spot warning, electronic stability control, forward collision warnings, and lane departure warnings would result in a 23.8 % reduction of crashes in the UK. Collectively, this research highlights the added safety that ADAS may have in reducing the seriousness of car crashes.

Emerging systems including audio speed alerts (an alert which warns the driver that they have reached their set speed), cruise control (enables the vehicle to continue driving at a set speed), adaptative cruise control (adjusts the speed of the vehicle to maintain a safe distance to the vehicle driving in front), and intelligent speed assist technology (system which actively adjusts the vehicle's speed to the posted speed limit by reducing engine power) may also be able to assist drivers to comply with the posted speed limit. Previous research has found some support for the potential effectiveness of advanced systems at reducing speeding behaviour. For example, Varotto et al. (2022) found that when adaptative cruise control was active in conjunction with lane keeping assist, drivers were less likely to speed than when driving without these systems. In contrast, Monfort et al. (2022), reported that drivers in their sample ($N = 40$) were more likely to speed when either adaptative cruise control or adaptive cruise control and lane centring was active compared to manual operation of the vehicle. In another study, Day et al. (2023) explored UK drivers' ($N = 40$) beliefs towards intelligent speed assistance systems and found that most participants in their sample perceived that this technology would reduce unintentional speeding of other drivers.

1.3. Current study

The purpose of this study was to examine which traditional and technology-based countermeasures (herein referred to as approaches) drivers perceived as effective in assisting them to comply with posted speed limits. Given that speeding behaviour contributes to on-road injuries and fatalities, not only in Australia where this research was undertaken, but worldwide (see: World Health Organization, 2017), there is a need to investigate if emerging vehicle technologies can be used to assist drivers to drive safely. To date, there has been an absence of research which has examined drives' perceptions of using audio alerts and ADAS to comply with posted speed limits. Thus, this research contributes to the existing literature by examining drivers' perceptions towards these advanced systems, and how they compare with their perceptions of existing traditional-based approaches in assisting them to comply with the posted speed limits.

The five approaches under investigation in the current study included ADAS, in-vehicle alerts, police enforcement, on-road messaging, and other (e.g., checking speedometer; see Appendix, for further detail of the approaches examined). Given that speeding behaviour may differ as a function of road environment (e.g., Cai et al., 2021) and speed zone (e.g., Perez et al., 2021; Yokoo & Levinson, 2019), the current study focused on examining speeding across four different road environments and speed zones, specifically (i.) urban 60 km/hr speed limit, (ii.) urban 100 km/hr speed limit, (iii.) regional 60 km/hr speed limit, and (iv.) regional 100 km/hr speed limit. In the current study, an urban environment was defined as an area with a population of more than 100,000 people and a regional environment was as any areas located outside of an Australian major capital city. The following two research questions were proposed:

RQ1. How common is speeding in the study sample?

RQ2. What approach/es do drivers perceive as the most effective at helping them to comply with the posted speed limit?

The rest of the paper is organised as follows. Section 2 presents the methodology of this study, including details on participants, study design, measures, and procedure. Section 3 presents the results and Section 4 discusses the findings, presents limitations and future research directions.

2. Method

2.1. Participants

A total of 776 participants commenced the online questionnaire. Of those, 19 individuals did not meet the participant eligibility criteria of holding a valid open (also known as full or unrestricted), provisional (novice restricted), or international driver licence (15 individuals reported holding a learner permit, and four individuals did not hold a driver licence) and 77 individuals did not complete the full questionnaire and therefore, were excluded from analysis. The final sample was 680 participants. Table 1 presents participant characteristics.

Table 1
Participants characteristics.

		n	%
Age	Range: 17–89 years M = 49.34 years, SD = 21.75		
Gender	Male	446	65.6
	Female	226	33.2
	Non-binary	4	0.6
	Other	2	0.3
	Prefer not to say	2	0.3
Licence type	Australian open driver licence	531	78.1
	Australian provisional licence	147	21.6
	International licence	2	0.3
Weekly driving hours	M = 11.53, SD = 12.88		

N = 680. All participants resided in Australia.

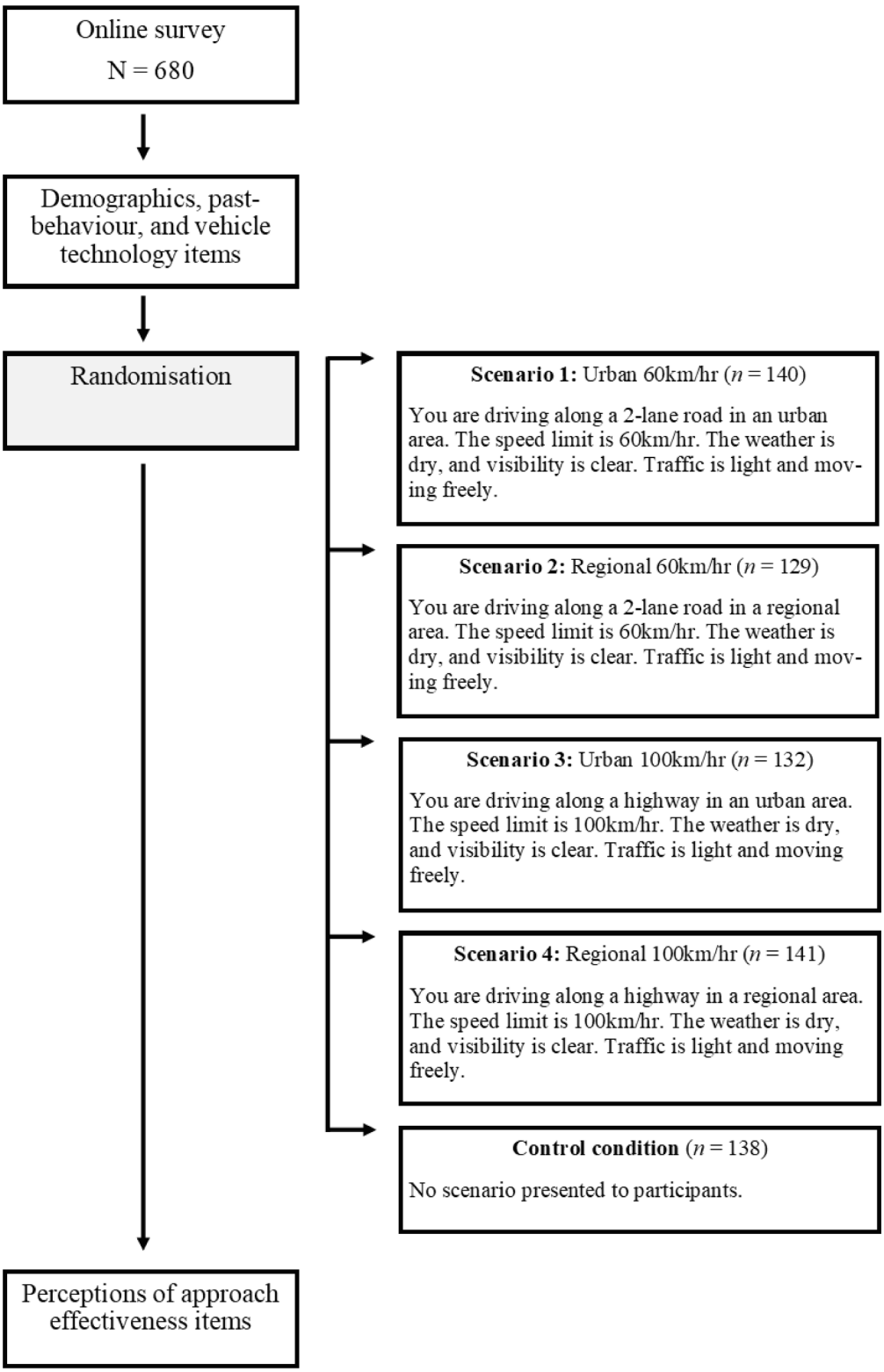

Fig. 1. Overview of the survey design. Note. The pictures presented with the written descriptions in the questionnaire are not provided due to copyright.

2.2. Design

The study was a between-groups design whereby participants in the experimental group were randomly assigned to read one of four driving scenarios which differed based on location (urban or regional) and posted speed limit (60 km/hr or 100 km/hr) or were assigned to the control condition with no given scenario. All other information (i.e., weather, visibility, and traffic volume) remained constant across all scenarios. Fig. 1 presents the flowchart of the survey design.

2.3. Measures

2.3.1. Demographics and descriptive questions

Demographic information included age, gender, licence type, Australian State or Territory of residence, and average hours of driving each week.

2.3.2. Engagement in speeding in the past (i.e., past behaviour)

To understand the sample and the extent to which they comprised drivers who reported having sped in the past, participants were asked, "Over the past 12 months, how often have you driven…." 1–5 km over the posted speed limit on (i.) a 60 km/hr road? (ii.) a 100 km/hr road?, 6–10 km/hr over the posted speed limit on (i.) a 60 km/hr road? (ii.) a 100 km/hr road?, and 11 + km/hr over the posted speed limit on (i.) a 60 km/hr road? (ii.) a 100 km/hr road?. Response options were provided on a 7-point Scale (1 = *Never*, 7 = *Always*). Participants were also asked, "Have you ever been fined for speeding behaviour" (yes/no) and if yes, "how many fine(s) in total have you received for speeding?" and "how many fine(s) have you received for speeding within the past 12 months?". In Australia, the amount of tolerance allowed in speed detection is not made available to the public. Speed offences in Australia involve a speeding fine and demerit (penalty) point/s, and sometimes may result in licence suspension depending on the offence. The more kilometres a person drives over the posted speed limit, the larger the fine and greater number of demerit points.

2.3.3. Vehicle technologies

The technologies of focus within the current research (and so chosen because they represented relatively common or increasingly available technologies within the Australian vehicle fleet) included: cruise control, adaptive cruise control, audio speed alerts (via vehicle), intelligent speed assist technology, and navigation systems. Participants were provided with a definition of each technology (see Table 2) and, to understand more once about the sample in terms of the aspects under investigation in this study, were asked, "Do you have any of these technologies in the vehicle which you drive most often? (yes/no/unsure). Participants were asked to rate their current knowledge of these technologies on a 7-point Scale (1 = *Poor*, 4 = *Average*, 7 = *Excellent*).

2.3.4. Approaches

A 7-point scale (1 = *Extremely Unlikely*, 7 = *Extremely Likely*) was used to rate participants' perceptions of the effectiveness of 17 different approaches at helping them to comply with the posted speed limit in the situation which they were assigned (see Appendix for items).

2.4. Procedure

The study was granted approval by the Queensland University of Technology (QUT) Human Research Ethics Committee (QUT Ethics Approval Number: 5607). Participants were recruited via a paid Facebook advertisement or other online advertising, such as LinkedIn ($n = 511$) or via the University's online recruitment system for undergraduate students ($n = 169$). Participants were asked to complete an online questionnaire hosted in Qualtrics. Participants first completed the demographic information (e.g., age and gender) then items which related to their past speeding. They were then asked to report which of the five specified ADAS vehicle technologies they had, before rating their current knowledge of these technologies. Participants were then randomly allocated via the Randomizer function in Qualtrics to one of the four experimental (scenario) conditions or to the control condition (no scenario). They then completed the items which related to which approaches that they would find effective at helping them comply to the posted speed limit in the scenario. The sample were recruited via Facebook or via other online advertising were offered entry into a prize draw to win one of four AU$100 gift vouchers and the undergraduate students recruited via the University's online recruitment system were offered 0.5 course credit points for completing the survey. On average, participants completed the survey within 20 min.

Table 2
Definitions.

Technology	Definition
Cruise control	Enables the vehicle to continue driving at a set speed
Adaptive cruise control	Adjusts the speed of the vehicle to maintain a safe distance to the vehicle driving in front
Audio speed alerts (via vehicle)	Provides an audio alert to the driver if the vehicle is exceeding the posted speed limit
Intelligent speed assist technology	If a driver is speeding, this system will actively adjust the vehicle's speed to the posted speed limit by reducing engine power
Navigation system	An in-vehicle system which aids navigation

3. Results

3.1. Data analysis

Preliminary data checks were first conducted to assess if there were any differences in participant demographics across the conditions. Descriptive statistics explored participants' self-reported prior speeding, knowledge, and presence of the five ADAS features in their vehicle. A mixed analysis of variance (ANOVA) was conducted to examine which approaches drivers perceived as effective at helping them to comply with the posted speed limit. As part of this ANOVA, previous speeding fine (yes/no) was also included to assess if speeding behaviour affected perceived effectiveness. To reduce the number of comparisons, the 17 approach items were grouped into five categories: ADAS, in-vehicle alerts, police enforcement/presence, on-road messages, and other (i.e., checking speedometer, speed limit on road markings, more frequent speed signs). The descriptives for the 17 approach items for each condition (i.e., urban 60 km/hr, regional 60/km/hr, urban 100 km/hr, regional 100 km/hr, and control condition) are presented in the online Supplement.

3.2. Preliminary data checks

Pearson chi-squares and one-way ANOVAs were conducted to explore if there were any significant differences between the five conditions in participants' age, gender, and self-reported prior engagement in speeding. Chi-square tests revealed that there were no significant differences between the conditions in gender, X^2 (16) = 14.57, $p = 0.556$, or previously receiving a speeding ticket, X^2 (4) = 3.11, $p = 0.540$. Similarly, one-way ANOVAs showed that there were no significant differences between each condition in age, $F(4, 679) = 1.45$, $p = 0.215$, or exceeding the posted speed limit by the following amounts: 1–5 km/hr on a 60 km/hr road, $F(4, 678) = 0.62$, $p = 0.647$, 6–10 km/hr on a 60 km/hr road, $F(4, 676) = 0.90$, $p = 0.461$, 11 + km/hr on a 60 km/hr road, $F(4, 675) = 1.30$, $p = 0.267$, 1–5 km/hr on a 100 km/hr road, $F(4, 676) = 0.88$, $p = 0.476$, 6–10 km/hr on a 100 km/hr road, $F(4, 677) = 1.05$, $p = 0.318$, and 11 + km/hr on a 100 km/hr road, $F(4, 676) = 1.27$, $p = 0.281$. Thus, it was considered that the randomisation was successful, and the five groups were essentially similar (i.e., no significant differences on sociodemographic or prior speeding engagement) prior to their being allocated to one of the study conditions.

3.3. Speeding and speeding fines

Participants were asked to report how often they had driven over the posted speed limit on 60 km/hr and 100 km/hr roads over the past 12 months. As presented in Table 3, more participants reported exceeding the posted speed limit by 1–5 km/hr compared to driving 11 + km/hr over the posted speed limit. Specifically, on a 60 km/hr road, 40.7 % of participants reported driving 1–5 km/hr over posted speed limit often to always, 16.9 % of participants reported driving 6–10 km/hr over the posted speed limit often to always, and 6.3 % of participants reported driving 11 + km/hr over the posted speed limit often to always. On a 100 km/hr road, 50.4 % of participants reported driving 1–5 km/hr over the posted speed limit often to always, 26.2 % of participants reported driving 6–10 km/hr over the posted speed limit often to always, and 11.5 % of participants reported driving 11 + km/hr over the posted limit often to always. Further, 441 (64.9 %) participants reported that they had received a fine for speeding, with 98 (22.2 %) of those participants reporting having received a speeding fine in the past 12 months. Of those 98 participants, 80 reported receiving one speeding fine in

Table 3
Participants' self-reported speeding behaviour on 60 km/hr and 100 km/hr roads.

	n (% of responses)						
Speed limit	Never	Very rarely	Rarely	Sometimes	Often	Very often	Always
Over the past 12 months, how often have you driven over the posted speed limit on a 60 km/hr road?							
1–5 km/hr over the posted speed limit?	29 (4.3)	140 (20.6)	77 (11.3)	156 (23.0)	123 (18.1)	102 (15.0)	52 (7.6)
6–10 km/hr over the posted speed limit?	177 (26.0)	156 (22.9)	121 (17.8)	108 (15.9)	57 (8.4)	39 (5.7)	19 (2.8)
11 + km/hr over the posted speed limit?	366 (53.8)	132 (19.4)	70 (10.3)	65 (9.6)	26 (3.8)	8 (1.2)	9 (1.3)
Over the past 12 months, how often have you driven over the posted speed limit on a 100 km/hr road?							
1–5 km/hr over the posted speed limit?	36 (5.3)	97 (14.3)	59 (8.7)	144 (21.3)	134 (19.8)	119 (17.6)	88 (13.0)
6–10 km/hr over the posted speed limit?	132 (19.4)	119 (17.5)	98 (14.4)	150 (22.1)	75 (11.0)	69 (10.1)	35 (5.1)
11 + km/hr over the posted speed limit?	279 (41.2)	147 (21.7)	93 (13.7)	80 (11.8)	30 (4.4)	35 (5.2)	13 (1.9)

the past 12 months, 13 participants reported receiving two speeding fines, four participants reported receiving three speeding fines, and one participant reported receiving more than three speeding fines in the previous 12 months.

3.4. Advanced technologies in current vehicle and knowledge

Table 4 shows that more than a third of the sample reported driving a vehicle with cruise control, with over half of the sample reporting driving a vehicle with a navigation system. Most of the sample reported not driving a vehicle with adaptive cruise control, audio speed alerts, or intelligent speed assist technology. A higher proportion of participants reported excellent knowledge about cruise control (48.7 %) and navigation systems (46.5 %) than intelligent speed assist technology (15.5 %), adaptive cruise control (26.5 %), and audio speed alerts (27.6 %) (see Table 5).

3.5. Perceived effectiveness of approaches to help drivers comply with posted speed limits

A 5 x 2 x 5 mixed factorial ANOVA, with conditions and previous speeding fine as the between groups factors and approaches as the within groups factors, was undertaken to assess which approaches participants perceived as the most effective at helping them to comply with the posted speed limit. The descriptive statistics are presented in Table 6.

Mauchly's Test of Sphericity was significant and therefore, the Huynh-Feldt has been reported as the multivariate test statistic. The finding revealed that there was no significant main effect of condition, $F(1, 669) = 1.01$, $p = 0.400$, and there was no significant main effect of previous speeding fine, $F(1, 669) = 0.46$, $p = 0.765$. However, there was a significant main effect of approach, $F(3.41, 2279.97) = 157.50$, $p < 0.001$. Pairwise comparisons with a Bonferroni corrected adjustment of $p < 0.001$, showed that participants reported significantly higher mean ratings that police enforcement strategies would be more effective at helping drivers' to comply with the posted speed limit compared to all other approaches; ADAS (mean difference = 1.31, std. error = 0.076, $p < 0.001$), in-vehicle alerts (mean difference = 1.37, std. error = 0.069, $p < 0.001$), messaging (mean difference = 1.56, std. error = 0.068, $p < 0.001$), and other approaches (mean difference = 0.89, std. error = 0.071, $p < 0.001$). There were also significantly higher mean ratings for other approaches when compared to ADAS (mean difference = 0.41, std. error = 0.076, $p < 0.001$), in-vehicle alerts (mean difference = 0.47, std. error = 0.071, $p < 0.001$), and messaging (mean difference = 0.66, std. error = 0.056, $p < 0.001$).

The findings also showed that there was a significant condition x approach interaction, $F(13.63, 2279.97) = 4.92$, $p < 0.001$ and a significant previous speeding fine x approach interaction, $F(3.41, 2279.97) = 5.18$, $p < 0.001$. The 3-way interaction of condition x previous speeding fine x approach interaction was not significant, $F(13.63, 2279.97) = 1.10$, $p = 0.358$. For the approach x scenario interaction, an examination of the simply main effects with a Bonferroni corrected adjustment of $p < 0.001$ revealed that drivers rated ADAS to be significantly more effective in the 100 km/hr urban condition compared to the 60 km/hr urban condition (mean difference = 1.20, std. error = 0.231, $p < 0.001$) and rated ADAS significantly more effective in the control condition compared to the 60 km/hr condition (mean difference = 1.16, std. error = 0.232, $p < 0.001$). There were no other significant simple main effects at $p < 0.001$. For the approach x previous speeding fine interaction, there were no simply main effects significant at a Bonferroni corrected adjustment of $p < 0.001$.

4. Discussion

This investigation examined how common speeding behaviour was in an Australian sample and which approaches drivers perceived as the most effective at assisting them to comply with posted speed limits across urban and regional locations in the future. The findings showed that low range speeding behaviour was a common behaviour in our sample (more than 50 % reporting speeding 1–5 km over the posted speed often to always in a 100 km/hr speed zone and more than 40 % in a 60 km/hr speed zone), which is consistent with previous research undertaken in Australia (e.g., Chevalier et al., 2016; Stephens et al., 2017). For example, Stephens et al. (2017) found that 47 % of their representative sample of 5,656 respondents reported driving over the posted speed limit. Further, Chevalier et al. (2016) found in their naturalistic driving study that exceeding the speed limit by 1–9 km/hr was a common occurrence in drivers aged 75 years or older. Collectively, these findings highlight that low-level speeding remains prevalent on Australian roads, highlighting the need for further action.

The findings revealed that participants perceived police enforcement would be most effective at assisting them to comply with posted speed limits in the future when compared to all other approaches (i.e., ADAS, in-vehicle alerts, on-road messages, and other approaches including checking speedometer and more frequent speed signs). Previous research has reported that the presence of police

Table 4
Number and percentage of ownership of advanced technology in vehicle.

	Yes	No	Unsure
Systems	n (% of responses)	n (% of responses)	n (% of responses)
Cruise control	526 (77.4)	141 (20.7)	13 (1.9)
Adaptive cruise control	167 (24.6)	468 (69.0)	43 (6.3)
Audio speed alerts	186 (27.4)	473 (69.7)	20 (2.9)
Intelligent speed assist technology	77 (11.3)	564 (83.1)	38 (5.6)
Navigation systems	431 (63.4)	239 (35.1)	10 (1.5)

Table 5
Self-reported knowledge of advanced technologies.

System	n (% of responses)						
	Poor			Average			Excellent
Cruise control	39 (5.7)	19 (2.8)	18 (2.7)	95 (14.0)	57 (8.4)	120 (17.7)	331 (48.7)
Adaptive cruise control	148 (21.9)	45 (6.7)	43 (6.4)	130 (19.2)	59 (8.7)	72 (10.7)	179 (26.5)
Audio speed alerts	126 (18.6)	43 (6.3)	39 (5.8)	129 (19.0)	70 (10.3)	84 (12.4)	187 (27.6)
Intelligent speed assist technology	221 (32.7)	72 (10.7)	62 (9.2)	123 (18.2)	44 (6.5)	48 (7.1)	105 (15.5)
Navigation Systems	39 (5.7)	0 (0.0)	30 (4.4)	92 (13.5)	64 (9.4)	138 (20.3)	316 (46.5)

Table 6
Descriptive statistics of the effectiveness of approaches to comply with the posted speed limit.

Approaches	Previous speeding fine	Mean scores (SD) Urban 60 km/hr	Regional 60 km/hr	Urban 100 km/hr	Regional 100 km/hr	Control
ADAS	Yes	4.32 (1.92)	4.93 (1.90)	5.27 (1.83)	5.01 (1.92)	5.18 (1.52)
	No	3.69 (1.96)	4.84 (1.92)	5.13 (1.51)	4.73 (1.73)	5.15 (1.68)
	Total	4.13 (1.95)	4.90 (1.90)	5.22 (1.71)	4.91 (1.85)	5.15 (1.57)
In-vehicle alerts	Yes	4.68 (1.67)	4.47 (1.71)	4.71 (1.56)	4.57 (1.79)	4.69 (1.56)
	No	4.71 (1.54)	4.85 (1.93)	5.05 (1.26)	4.94 (1.36)	4.93 (1.78)
	Total	4.69 (1.63)	4.61 (1.79)	4.84 (1.45)	4.70 (1.65)	4.76 (1.64)
Police enforcement/presence	Yes	6.05 (1.22)	6.12 (1.19)	6.18 (1.32)	5.84 (1.49)	6.33 (0.84)
	No	6.41 (1.12)	6.06 (1.53)	6.11 (1.17)	6.05 (1.41)	6.14 (1.32)
	Total	6.15 (1.20)	6.10 (1.32)	6.16 (1.26)	5.92 (1.46)	6.23 (1.03)
On-road messages	Yes	4.84 (1.60)	4.47 (1.84)	4.27 (1.79)	4.33 (1.81)	4.58 (1.69)
	No	4.76 (1.70)	4.86 (1.72)	4.86 (1.34)	4.28 (1.60)	4.47 (1.38)
	Total	4.81 (1.63)	4.61 (1.80)	4.50 (1.65)	4.31 (1.74)	4.54 (1.58)
Other approaches	Yes	5.33 (1.45)	5.01 (1.63)	4.82 (1.70)	4.92 (1.77)	5.21 (1.44)
	No	5.35 (1.47)	5.39 (1.55)	5.62 (1.23)	5.21 (1.48)	5.45 (1.45)
	Total	5.34 (1.45)	5.15 (1.61)	5.14 (1.57)	5.02 (1.67)	5.30 (1.44)

Note. 1 = Extremely unlikely, 7 = Extremely likely. ADAS = cruise control, adaptive cruise control, intelligent speed assist technology. In-vehicle alerts = audio speed alerts via vehicle, navigation systems, mobile phone application. Enforcement = presence of a fixed camera, mobile camera, point-to-point cameras, or police vehicle. On-road messages = passing a smiley-face speed awareness monitor, variable message sign displaying a 'slow down' message, or presence of a billboard displaying a 'slow down' message. Other = checking speedometer, speed limit on road markings, more frequent speed signs.

enforcement reduces drivers' speeds (e.g., Simpson et al., 2020) and increased enforcement levels are associated with a reduction of speeding (Ryeng, 2012). Other research has reported that fixed and mobile speed cameras are effective at reducing crashes (e.g., Cameron & Newstead, 2021; Christie et al., 2003; Wilson et al., 2010). However, and despite the effectiveness of these police enforcement countermeasures, it is not uncommon for Australian drivers to express negative attitudes towards enforcement countermeasures, including the misperception that speed enforcement is a means of revenue raising (e.g., van Souwe et al., 2018). While the current findings suggest that police enforcement countermeasures are an effective approach at assisting drivers to comply with posted speed limits, it is important to continue to convey to drivers that police speed enforcement strategies are implemented to reduce crashes and that the money gained from speed camera fines in Australia is used to fund road safety initiatives.

Additionally, the findings also showed that participants perceived other approaches (i.e., checking the speedometer, speed limit displayed on road, and more frequent speed signs) would be more effective than ADAS, in-vehicle alerts, and messaging. This finding highlights the importance of displaying road limits and frequent speed signs to communicate speed limits to drivers. Previous research has reported that sign repetition (e.g., Jongen et al., 2011) and road markings (e.g., Charlton et al., 2018) may influence speed choice. For instance, in an experimental driving simulator study, Jongen et al. (2011) found that drivers exceeded the posted speed limit more often when there was less repetition of speed signs. These authors concluded that repetition of speed signs is needed to assist with speed compliance. In another driving simulator study, Charlton et al. (2018) examined whether information about speed limits could be delivered via on-road markings. They found that drivers who were told the meaning of the different speed limit road markings complied with the posted speed limits than groups of drivers who did not receive this information. Collectively, this research highlights the importance of road markings and speed signs in assisting with compliance of the posted speed limits.

The current study also found that participants reported that ADAS (comprising of cruise control, adaptative cruise control, and intelligent speed assist technology) would be more effective at assisting them to comply with the posted speed limit in the 100 km/hr

urban condition when compared to the 60 km/hr urban condition. It could be speculated that participants would be more likely to activate cruise control and adaptative cruise control on higher speed urban roads as drivers are more likely to maintain a set speed on these roads compared to lower speed urban roads where traffic speed is less consistent due to other environment factors (e.g., higher number of traffic intersections and roundabouts). Previous research has found that drivers perceive ADAS, such as adaptive cruise control, to be of greater assistance on longer trips to assist with speed maintenance than on shorter drives (Orlovska et al., 2020). Despite the finding that participants perceived ADAS would be more effective in 100 km/hr than 60 km/hr urban conditions, the study also showed that most participants reported not owning a vehicle with adaptive cruise control and intelligent speed assist technology, with over half of respondents reporting poor to average knowledge of these two systems. Therefore, it is important to educate drivers about the capabilities of these systems and how they can be used to assist with speed management, and to determine whether this results in more positive perceptions.

The investigation shows a deeper value conflict between safety and freedom/autonomy that may resonates with some drivers. While drivers recognise the effectiveness of enforcement-based countermeasures, they prefer less intrusive approaches that allow them to maintain autonomy. For example, drivers favour methods like frequent speed limit signs, clear road markings, and regular speedometer checks over police enforcement or speed cameras. These preferred approaches serve to inform and remind drivers of speed limits, helping them comply without feeling punished or controlled. In contrast, enforcement measures, although effective, are often perceived as punitive and restrictive, leading to negative perceptions. Thus, drivers lean towards strategies that support their autonomy while promoting safe driving practices. This tension reveals a fundamental challenge in road safety efforts: how to effectively balance the imperative of protecting public safety with respecting individual freedom. Drivers' preference for retaining control over their driving decisions, even in the context of interventions aimed at reducing speeding, highlights the importance of considering these values when designing and implementing road safety measures. Addressing this value conflict requires thoughtful dialogue and innovative solutions that can reconcile the dual goals of safety and autonomy, ensuring that road safety interventions are both effective and respectful of individual preferences.

4.1. Limitations and future research

The present study has some limitations. Firstly, a convenience sample was recruited, and participants may not be a true representation of drivers in Australia. Secondly, the study is based on self-reported perceptions instead of assessing the effectiveness of approaches to help comply with posted speed limits via objective measures (e.g., measuring behaviour via a driving simulator or on-road). Thirdly, the sample included some drivers who reported not driving an ADAS-equipped vehicle and some drivers who reported poor knowledge about two of the three systems included in this study, specifically adaptive cruise control and intelligent speed assist technology. Future research should further investigate drivers' perceptions of using ADAS to avoid exceeding the posted speed limit in a sample of drivers who regularly drive an ADAS-equipped vehicle. Fourthly, and to reduce the number of comparisons made when analysing data, the 17 types of approaches were group into five categories. It could be possible that one approach within a group may have functioned particularly better (or worse) than the rest of the approaches within specific groups. Fifthly, the current research primarily focused on technology that assists drivers in adhering to speed limits, but this perspective is somewhat simplistic because there may also be technologies that help drivers evade police enforcement when speeding (Truelove et al., 2023). Future research should investigate whether there are interactions between risky behaviours and technologies designed to maintain speed compliance, and how these may be influenced by technology that could enable avoidance of enforcement, potentially overshadowing the safety benefits. Finally, the study did not allocate people to specific scenarios based on where participants reported driving most frequently and did not examine speeding behaviour in rural locations. Previous research has reported that strategies that are most relevant and useable to an individual are likely to be the most effective (e.g., Lewis et al., 2016). Therefore, it is recommended that future research assesses ways in which drivers believe they can avoid speeding in environments where they frequently drive and whether these differ to the general perceptions measured in this study.

4.2. Conclusion

The study contributes to the existing literature by examining a sample of Australian drivers' perceived effectiveness of traditional and technology-based approaches in assisting them to comply with posted speed limits (60 km/hr and 100 km/hr) in regional and urban areas. This study employed a between-groups design, whereby 680 participants were randomly assigned to read one of four scenarios, or to a control condition (no scenario). It was found that more than 50 % of the sample reported regularly exceeding the posted speed limit by 1–5 km in 100 km/hr speed zones, and more than 40 % in 60 km/hr speed zones. These finding highlights that more needs to be done to assist with speed management in Australia. Further, the findings also showed that police enforcement was reported to be the most effective approach at assisting drivers to comply with posted speed limits, and that ADAS were perceived by drivers as being more effective in 100 km/hr urban roads than 60 km/hr urban roads. Overall, these findings have important implications for policy and practice, such as continuing roadside police presence on Australian roads to discourage speeding behaviour and promoting the use of ADAS on high-speed urban roads to assist with speed compliance. Speeding behaviour significantly contributes to road crashes and subsequent fatalities and serious injuries, and therefore, it is important that further research continue to investigate the effectiveness of speeding-related countermeasures.

CRediT authorship contribution statement

Sherrie-Anne Kaye: Writing – original draft, Project administration, Methodology, Formal analysis, Conceptualization. **Natalie Watson-Brown:** Writing – review & editing, Methodology, Conceptualization. **Ioni Lewis:** Writing – review & editing, Methodology, Conceptualization. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Methodology, Conceptualization. **Teresa Senserrick:** Writing – review & editing, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Acknowledgments

This research was supported by funding from the Motor Accident Insurance Commission (MAIC) Queensland and QUT. The views expressed herein are those of the authors and are not necessarily those of the funders.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2024.06.010.

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