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Truelove, V., & Oviedo-Trespalacios, O. (2026). How visibility and alerts shape speed enforcement legitimacy. *Transportation Research Part F: Traffic Psychology and Behaviour*, 119, Article 103592. <https://doi.org/10.1016/j.trf.2026.103592>

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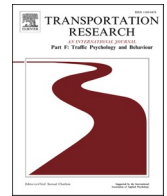
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Transportation Research Part F: Psychology and Behaviour

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

How visibility and alerts shape speed enforcement legitimacy

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A B S T R A C T

Speeding remains a leading contributor to road fatalities in Australia, with enforcement technologies such as speed cameras playing a central role in prevention efforts. This study investigated how perceptions of legitimacy—based on Tankebe's multidimensional model—differ between overt and covert speed cameras, and how these perceptions are influenced by the use of enforcement notification technologies (e.g., Google Maps, Waze). A cross-sectional survey of 1168 Australian drivers measured speeding behaviour, use of enforcement-avoidance technology, and perceptions of legitimacy across five constructs: lawfulness, obligation to obey, procedural fairness, distributive fairness, and camera effectiveness. Findings showed that overt cameras were perceived as significantly more fair and effective than covert ones. Technology users reported more frequent speeding, particularly at high levels, greater awareness of covert cameras and significantly lower perceptions on a number of the legitimacy variables than those that do not use the technology. Across both low- and high-level speeding models, the legitimacy constructs of lawfulness and obligation to obey the law were the strongest predictors of reduced speeding, while perceptions tied to specific enforcement methods were not significant. These results highlight the importance of fostering broad legal legitimacy. As enforcement systems increasingly intersect with digital technologies, maintaining public trust and reinforcing moral alignment with traffic laws may be key to supporting long-term compliance and reducing road risk.

1. Introduction

Speeding continues to be one the largest contributor to road fatalities ([World Health Organisation, 2023](#)). Not only does speeding increase the risk of crashing, but it also increases the severity of a crash ([Aarts & Van Schagen, 2006](#)). Speed cameras are one of the primary enforcement methods in place to prevent this risky behaviour ([Amancio et al., 2024](#); [Freeman, Kaye, Truelove, & Davey, 2017](#)). Broadly, speed cameras can be classified as overt (very visible, such as with signage and/or brightly painted cameras) or covert (not as obviously visible, e.g., unmarked). However, the existence of driving applications that can notify drivers of speed camera enforcement locations (e.g., Google Maps, Waze) means that drivers may be aware when they are driving past both types of cameras, which could be limiting the effects of covert speed cameras. It also possible that the use of these applications are undermining perceptions of legitimacy associated with these speed cameras. Previous research has suggested when drivers have low perceptions of legitimacy, enforcement is less effective at preventing offending behaviour ([Anderson, Bates, & Schaefer, 2025](#); [Tankebe, 2012](#)), highlighting the importance of legitimacy associated with enforcement. Given these gaps in the literature, this study aimed to examine the differences in perceived legitimacy between overt and covert speed cameras, as well as users and non-users of driving applications. Further, the study aimed to determine if the use of the driving applications and perceptions of legitimacy impacted speeding behaviour.

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<https://doi.org/10.1016/j.trf.2026.103592>

Received 9 July 2025; Received in revised form 15 January 2026; Accepted 15 March 2026

Available online 27 March 2026

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Previous research has demonstrated the effectiveness of overt and covert enforcement can vary. [Champness, Sheehan, and Folkman \(2005\)](#) demonstrated that mobile overt speed cameras successfully reduced speeding, yet this effect was limited to a small area, as their effect was removed within 1500 m downstream of the camera. In a simulator study, [Marciano, Setter, and Norman \(2015\)](#) found that covert speed camera conditions resulted in lower median speeds and less variance in speeding behaviour compared to overt speed camera conditions. Meanwhile, it was found that after a trial for a series of overt speed cameras were changed to covert speed cameras (in conjunction with advertising and signage in the general area saying “hidden camera may operate”), reductions were found in speeding behaviour, crashes and road deaths compared to the pre-trial period ([Keall, Povey, & Frith, 2001](#)). This effect was found to be sustained over the following two years ([Keall, Povey, & Frith, 2002](#)). When comparing more covert speed enforcement systems in Victoria, Australia to more overt speed enforcement systems in Sweden, it was found that both systems delivered significant road safety benefits ([Belin, Tillgren, Vedung, Cameron, & Tingvall, 2010](#)). In another study, [Diamantopoulou and Cameron \(2002\)](#) examined the effects of different types of mobile radar enforcement, including overt, covert and a mixture of both overt and covert police vehicle used during the speed enforcement sessions. It was found that a mixture of both overt and covert enforcement was the most effective at reducing casualty crashes, with significant reductions in these crashes found compared to the two-year period prior to deployment of the mobile radar enforcement. Overall, these studies demonstrate how covert speed cameras can have advantages over overt speed cameras when it comes to reducing speeding behaviour and crashes yet using both overt and covert speed cameras may provide an optimal benefit.

Notably, there has been limited recent research into the effectiveness of overt and covert speed cameras, which may at least in part be due to the widespread implementation of speed cameras that make randomised control trials much more difficult to implement. However, this means that there is limited recent research to help us understand the effectiveness of overt and covert speed cameras in a time period where it is much easier for drivers to be notified of all types of camera locations, such as via social media (e.g., Facebook speed camera location pages) and driving applications such as Google maps, Waze and Apple Maps that can notify drivers of speed enforcement ([Truelove, Nicolls, Stefanidis & Oviedo-Trespalacios, 2023](#)). Research has demonstrated that drivers who have an active phone application that has this feature are significantly more likely to speed than those who don't have an active application ([Truelove, Nicolls, Stefanidis & Oviedo-Trespalacios, 2023](#)). A qualitative study found that for some drivers, the use of this technology can help them regulate their speeding behaviour more often, as they are more aware of enforcement while for other drivers, it helps them violate road rules with more perceived invincibility because they believe they would always know where enforcement is ([Truelove, Nicolls, & Oviedo-Trespalacios, 2025](#)). Currently, it is unknown how the use of this technology impacts overt vs covert speed camera enforcement. It is likely drivers would be more aware of covert speed cameras with the use of this technology, yet this needs to be explored further.

When considering overt and covert speed enforcement, an important factor to consider is drivers' perceptions towards these cameras. Research has demonstrated that perceptions of legitimacy towards police can impact rule compliance and cooperation with police ([Anderson et al., 2025; Tankebe, 2012](#)). Tyler (1990) originally defined legitimacy as individuals accepting that their behaviour should be consistent with expectations of an external authority. More recently, [Tankebe \(2012\)](#) argued that this definition places too much importance on obligation to obey the law, yet perceived legitimacy is more complex than this as an obligation to obey the law may be a result of fear or a powerlessness, not necessarily perceptions of legitimacy of the law. As such, [Tankebe \(2012\)](#) provided an updated multidimensional definition of legitimacy, that includes the obligation to obey the law as well as four additional factors. This includes lawfulness, which is the idea that legal power is consistent with rules that are already established within society. The remaining three factors come under the overarching umbrella of shared values. First, there is procedural fairness, which is the level of fairness that is perceived in the process of reaching a legal decision. Next, there is distributive fairness, meaning 1) the legal outcomes are fair and 2) the distribution of these outcomes (e.g., between different groups of people) are also fair. There is also effectiveness, which states that the results of the legal outcomes are effective in what they aim to do.

Perceived legitimacy has primarily been applied to police enforcement, with only limited attention to camera enforcement. For example, a qualitative UK study found that speed cameras can create a conflict between an individual's identity as a “normal” non-criminal driver and a perceived underlying assumption associated with the camera technology that drivers are criminal, creating perceptions of injustice associated with the cameras ([Wells & Wills, 2009](#)). Further, it has been identified that even though cameras can provide more consistent and non-discriminatory outcomes than police, they are still viewed as unfair since drivers believe speed limits are not always fair, and the cameras don't consider the circumstances of the driver ([Wells, 2008](#)). Previous research has also demonstrated that the procedural justice construct of normality (making decisions on facts, not biases or personal beliefs) was important for young drivers in terms of both point-to-point and mobile speed cameras ([Bates, Allen, & Watson, 2016](#)). A further study found that less perceived legitimacy can increase speed ticket contestation rates, after drivers were exposed to a billboard labelling speed enforcement as a speed trap ([Ward, Nobles, Lanza-Kaduce, Levett, & Tillyer, 2011](#)). Notably, there has been no research that has applied [Tankebe's \(2012\)](#) multidimensional measures of legitimacy to speed cameras. Further, research has also not applied the perceived legitimacy constructs to differentiate between overt and covert speed cameras. Given that driving applications can notify drivers of the locations of speed cameras, it may also be possible that perceptions of legitimacy would differ between those that use the applications compared to those that don't use the applications, yet this also has not been studied in the literature.

Given the gaps in the literature, the aim of this study was to apply the multidimensional model of legitimacy to the context of speed camera enforcement and examine how these perceptions vary across different enforcement types and driver behaviours. Specifically, the study sought to investigate differences in perceived legitimacy between overt and covert speed cameras, and between drivers who use enforcement notification technologies and those who do not. In doing so, the research aimed to provide a deeper understanding of how legitimacy perceptions relate to actual speeding behaviour, both at lower and higher levels of offence, and how technology use may influence these relationships. More specifically, this study had the following research questions:

- 1) How do perceptions associated with the multidimensional factors of legitimacy compare between overt and covert speed cameras?
- 2) How does speeding behaviour and awareness of overt and covert speed cameras differ between drivers who use driving applications, compared to those who don't use driving applications
- 3) How do perceptions of speed camera legitimacy differ between drivers who use driving applications, compared to those who don't use driving applications
- 4) How does the use of driving applications and perceptions of legitimacy impact 1) low level speeding and 2) high level speeding

2. Method

2.1. Procedure

A cross-sectional online survey was distributed to drivers across Australia. To be eligible for the study, participants had to be aged 17 years and over and hold an Australian drivers licence. Participants were recruited via paid Facebook advertising. In addition, a newsletter, flyers, posters and emails were disseminated to the authors' institutions. Participants were first provided with an online consent form and then completed the online survey with Qualtrics. The survey took approximately 25 min to complete. Once a participant completed the survey, they were able to enter a prize draw to win 1 of 20 AUD\$50 gift vouchers. Alternatively, first year psychology students were also recruited and had the ability to earn 1 course credit point upon completion of the survey. University ethics approval was granted for this study (A211660).

2.2. Participants

A total of 1168 participants completed the survey. The mean age of participants was 48.82 years ($SD = 20.46$) and on average, participants have held their driving licence for 31.06 years ($SD = 20.24$) and reported driving an average of 14.65 h per week ($SD = 31.50$). Further demographic variables, including gender, rurality, speeding ticket history in the past five years and use of technology that has told them the location of traffic enforcement cameras is reported in [Table 1](#). (See [Table 1](#)).

2.3. Materials

2.3.1. Demographics

Participant demographic material, including age, gender, length of time holding drivers licence, average hours driving per week, rurality and history of receiving a speeding ticket in the last 5 years were asked.

2.3.2. Speeding behaviour

Three questions were developed to understand different types of speeding behaviour, based on previous research ([Truelove, Freeman, et al., 2021](#)) and further developed to suit the aims of the study. Participants were asked "In the past month, how often have you engaged in the following behaviours?" with responses a 5-point Likert-type scale ranging from "never" to "nearly all the time". The behaviours included "You go over the speed limit by 1km/h or more", "You go 10 or more km/h over the speed limit" and "You drive over the speed limit in areas where it is unlikely that there is a radar or speed camera".

2.3.3. Experience with speed cameras

To understand the extent to which drivers view overt and covert speed cameras, participants were asked the following questions: "In the past two weeks, how many times have you seen a speed camera while driving?" If the participant answered 1 or more, this question was followed up with "How many were supposed to be visible?", "How many were supposed to be hidden?"

Table 1
Self-reported demographic information from participants.

	N (%)
Gender	
Male	660 (56.5%)
Female	508 (43.5%)
Rurality	
Metropolitan	548 (46.9%)
Regional	485 (41.5%)
Rural	135 (11.6%)
Speeding ticket history (past 5 years)	
Received speeding ticket	387 (33.1%)
Has not received speeding ticket	781 (66.9%)
Uses enforcement location technology	
Yes	712 (61.0%)
No	442 (37.8%)

Table 1
Means, standard deviations and frequencies of self-reported speeding.

	M (SD)	1	2	3	4	5
Speeding by 1 km/h or more	2.99 (1.15)	58	441	283	226	160
Speeding 10 km/h or more	1.70 (0.89)	597	390	128	36	17
Speeding when it is unlikely there is speed enforcement	2.24 (1.11)	317	482	201	105	63

2.3.4. Experience with punishment avoidance technology

To understand the technology that drivers use that have the ability to notify of them of traffic enforcement locations, participants were asked the following questions: "Have you ever used technology that has told you the location of traffic enforcement cameras (e.g., Google Maps, Apple Maps, Waze, Facebook police location pages, in vehicle technology)?"

2.3.5. Perceived legitimacy

The five facets of perceived legitimacy (lawfulness, obligation to obey the law, procedural fairness, distributive fairness and police effectiveness) were developed based on Tankebe (2012). The measures were amended to apply to speed enforcement as well as overt and covert speed cameras where relevant. Lawfulness and obligation to obey the law were worded to apply to the speeding law, to ensure accuracy with the constructs. Lawfulness was measured with the item "The speeding law represents the moral values of people like me" and obligation to obey the law was measured with the item "You should obey the speeding law because that is the proper or right thing to do." The procedural fairness items were worded to apply to speed cameras in general, as the procedures surrounding speed cameras are consistent regardless of whether the camera is overt or covert. Two items measured procedural fairness, including "Speed cameras use rules and procedures that are fair to everyone" and "Unfair decisions caught by speed cameras can be corrected". These items had a strong correlation ($r = 0.525, p < .001$). Distributive fairness and police effectiveness (changed to camera effectiveness for the purpose of this study) were worded to apply separately to overt and covert speed cameras, as it is likely these constructs would differ based on the different type of cameras. Two items were used to measure distributive fairness for overt speed cameras, including "People often receive fair outcomes from visible speed cameras" and "People usually receive the outcomes they deserve when caught by a visible speed camera". These items were strongly correlated ($r = 0.725, p < .001$). The same two items were also used to measure distributive fairness for covert speed cameras, with the wording of "visible" changed to "hidden". These items also had a strong correlation ($r = 0.886, p < .001$). All of the above questions included responses that were measured on a 4-point scale from 1 (strongly disagree) to 4 (strongly agree). For covert camera effectiveness, participants were asked "Indicate how well you think hidden speed cameras do in: 1) Increasing road safety" and 2) "Preventing engagement in speeding". These items were strongly correlated ($r = 0.807, p < .001$). Participants were asked the same questions related to overt speed cameras, with the wording "hidden" changed to "visible". These items had a strong correlation ($r = 0.828, p < .001$). These questions were measured on a 7-point scale from 1 (not at all well) to 7 (very well).

2.4. Data analysis

The data was treated as continuous for analysis purposes. Previous research has indicated that variables with Likert-type scales can be treated as continuous provided the data is normal, and the sample size is large (Huh & Gim, 2025; Rhemtulla, Brosseau-Liard, & Savalei, 2012). The perceived legitimacy constructs are operationalised as observed variables as they are direct measures derived from established survey items, meaning *t*-tests and regressions are appropriate analyses for these variables. To compare drivers' perceived legitimacy of overt vs covert speed cameras, paired sample *t*-tests were conducted on the distributive fairness and camera effectiveness variables for each type of camera (excluding the other perceived legitimacy variables, as they were related to the speed law or speed enforcement more generally). An independent sample *t*-tests was conducted to compare the ages of those that use and do not use the technology that notifies drivers of traffic enforcement locations, while a Pearson chi-square test was conducted to determine if technology use differs between genders. Meanwhile, a series of independent sample *t*-tests were conducted to understand the differences between users and non-users of technology that notifies drivers of traffic enforcement locations for different types of speeding behaviours, actively looking for speed cameras and exposure to speed cameras in general, exposure to overt and covert speed cameras, and legitimacy perceptions. As this set of 14 *t*-tests uses the same variable of use/non-use of the technology, Bonferroni adjustments were made where the 0.05 significance level was divided by 14, resulting in a significance level of 0.004. Statistics for equal variances assumed were reported when Levene's test was not breached, while the statistics for equal variances not assumed were reported when Levene's test was breached. Hedges *g* was reported for effect size when the sample size was different between groups and Cohen's *d* was reported for effect size when the sample size was equal between groups. The two-sided *p* value was reported for all *t*-tests. Next, two regressions were conducted to examine the impact of the use of driving applications and perceptions of legitimacy for 1) overt cameras and 2) covert cameras on general speeding behaviour (exceeding the speed limit by 1 km/h or more). A further two regression were conducted to examine the impact of the use of driving applications and perceptions of legitimacy for 1) overt cameras and 2) covert cameras on exceeding the speed limit by 10 km/h or more. As explained in the method, note that only the legitimacy variables of distributive fairness and camera effectiveness applied to overt and covert cameras specifically. A Bonferroni adjustment was also made for each set of two regressions, where the significance level of 0.05 was divided by 2, resulting in a significance level of 0.025. Unless otherwise stated, all assumptions were met.

3. Results

3.1. Frequencies of responses

Tables 1, 2 and 3 displays the means, standard deviations and frequencies for the key variables.

3.2. Differences in perceived legitimacy between overt and covert speed cameras

Table 4 shows the results of the *t*-tests comparing the perceived legitimacy variables between covert and overt speed cameras (noting that only two of the perceived legitimacy variables were specific to these types of cameras). It was found that both perceived distributive fairness and camera effectiveness were significantly higher for overt speed cameras compared to covert speed cameras.

3.3. Demographics of technology users and non-users

Drivers who reported using technology that notifies them of enforcement locations were significant younger ($M = 44.04$, $SD = 20.41$) than drivers who did not report using the technology ($M = 56.10$, $SD = 18.24$), $t(1010.77) = 10.42$, $p < .001$, with a medium effect size, $hedges\ g = 0.61$. Pearson chi-square test revealed there was no significant difference in technology use between genders ($p = .907$).

3.4. The use of technology that notifies drivers of enforcement locations, speeding behaviour and exposure to speed cameras

Table 5 displays the *t*-test results comparing uses and non-users of technology that notifies drivers of enforcement locations for different types of speeding behaviour and exposure to the different types of speed cameras. Drivers who used the technology engaged in all types of speeding behaviour more frequently than drivers who did not use the technology ($p < .001$). Drivers who used the technology were also significantly more likely to actively look for speed cameras while driving compared to those who didn't use the technology ($p < .001$). As the Bonferroni correction was applied to the *t*-tests (results are considered significant at $p < .004$), there was no significant difference between users and non-users of the technology in terms of number of overt speed cameras that were seen over the past two weeks ($p = .014$). However, technology users did report seeing significantly more speed cameras in general ($p < .001$), as well as significantly more covert speed cameras ($p < .001$) compared to non-users.

3.5. The use of technology that notifies drivers of enforcement locations and perceived legitimacy

Table 6 demonstrates that the perceived legitimacy variables of lawfulness and obligation to obey the law that referred to perceptions of the speeding law, were significantly higher among those who don't use the technology, compared to those that do use the technology ($p < .001$). There was no significant difference in procedural fairness between those that used and did not use the technology ($p = .005$). In terms of the perceived legitimacy variables that were specific to overt and covert cameras, it was found that there was no significant difference in the perceived distributive fairness of overt speed cameras ($p = .036$) and effectiveness of overt speed cameras ($p = .043$) between those that use the technology and those that don't use the technology. Meanwhile, those who reported not using the technology reported significantly higher perceptions of distributive fairness for covert speed cameras ($p < .001$) and effectiveness of covert speed cameras ($p < .001$) compared to drivers who reported they did use the technology.

3.6. Regressions

Table 7 shows the linear regression results for exceeding the speed limit by 1 km/h or more. The model for perceived legitimacy and overt speed cameras predicting exceeding the speed limit by 1 km/h or more was statistically significant, $F(9, 1040) = 43.485$, $p < .001$, $adjusted\ R^2 = 0.267$. Meanwhile, the model for perceived legitimacy and covert speed cameras predicting exceeding the speed limit by 1 km/h or more was statistically significant, $F(9, 1040) = 43.470$, $p < .001$, $adjusted\ R^2 = 0.267$. The significant predictors were consistent across both regressions. Age was statistically significant, indicating young drivers are more likely to speed. Drivers who used the technology were also significantly more likely to speed. Participants who scored higher on the legitimacy variables of lawfulness and obligation to obey the law were significantly less likely to speed. The legitimacy variables of distributive fairness and camera effectiveness (that were worded to apply specifically to overt or covert cameras) were not significant predictors of speeding for

Table 2

Means, standard deviation and frequencies of responses for procedural fairness, distributive fairness, lawfulness and obligation to obey the law.

	M (SD)	1	1.5	2	2.5	3	3.5	4
Procedural fairness	2.38 (0.97)	217	133	153	195	190	146	102
Distributive fairness for overt cameras	2.78 (0.98)	129	69	145	134	278	123	258
Distributive fairness for covert speed cameras	2.50 (1.11)	268	59	194	69	231	56	259
Lawfulness	2.56 (1.11)	274	0	246	0	326	0	290
Obligation to obey the law	2.98 (1.03)	140	0	192	0	356	0	448

Table 3
Means, standard deviation and frequencies of responses for perceived effectiveness of cameras.

	M (SD)	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Effectiveness of covert cameras	2.86 (1.92)	391	74	113	54	69	48	94	43	82	35	55	15	56
Effectiveness of overt cameras	4.50 (1.97)	114	25	79	30	75	47	124	44	128	66	153	38	206

Table 4
Perceived legitimacy compared between overt and covert speed cameras.

Variable	Overt speed cameras	Covert speed cameras	t-test results			
	M (SD)	M (SD)	df	t	p	Cohen's d
Distributive fairness	2.78 (0.98)	2.50 (1.11)	1135	11.584	<0.001	0.344
Camera effectiveness	4.50 (1.97)	2.86 (1.92)	1128	25.025	<0.001	0.745

Table 5
Comparisons in speeding behaviours and awareness of speed cameras between users and non-users of the technology.

Variable	Uses the technology	Doesn't use the technology	t-test results			
	M (SD)	M (SD)	df	t	p	Hedges g
Exceeds the speed limit when it is unlikely there is a radar or speed camera	2.42 (1.15)	1.95 (0.97)	1055.10	7.52	<0.001	0.436
Exceed the speed limit by 1 km/h or more	3.18 (1.16)	2.70 (1.07)	994.12	7.16	<0.001	0.425
Exceeding the speed limit by 10 km/h or more	1.82 (0.95)	1.52 (0.75)	1085.54	5.96	<0.001	0.342
Actively looks for speed cameras while driving	3.59 (1.34)	2.83 (1.44)	882.47	8.93	<0.001	0.550
Number of times a speed camera was viewed in the past two weeks (generally)	5.80 (3.59)	4.12 (3.13)	1030.29	8.36	<0.001	0.490
Number of overt speed cameras viewed in the past two weeks	4.91 (6.99)	3.82 (5.75)	710.77	2.47	0.014	0.164
Number of covert speed cameras viewed in the past two weeks	1.93 (4.25)	1.07 (1.93)	854.78	4.10	<0.001	0.236

Note. After Bonferroni adjustments, results are considered significant at the 0.004 level.

Table 6
Comparisons of perceived legitimacy between users and non-users of the technology.

Variable	Uses the technology	Doesn't use the technology	t-test results			
	M (SD)	M (SD)	df	t	p	Hedges g
Lawfulness	2.44 (1.11)	2.75 (1.10)	1134	-4.61	<0.001	-0.281
Obligation to obey the law	2.90 (1.04)	3.11 (1.00)	1134	-0.3.351	<0.001	-0.204
Procedural fairness	2.31 (0.96)	2.48 (0.98)	1134	-2.819	0.005	-0.172
Distributive fairness for overt speed cameras	2.73 (0.98)	2.85 (0.97)	1134	-2.096	0.036	-0.128
Distributive fairness for covert speed cameras	2.39 (1.10)	2.69 (1.11)	1134	-4.489	<0.001	-0.274
Effectiveness of overt speed cameras	4.40 (1.98)	4.65 (1.94)	1127	-2.023	0.043	-0.124
Effectiveness of covert speed cameras	2.66 (1.82)	3.18 (2.03)	1127	-4.437	<0.001	-0.271

Note. After Bonferroni adjustments, results are considered significant at the 0.004 level.

either overt or covert speed cameras. Gender, average hours driving, and procedural fairness were also non-significant predictors for both regressions.

Table 8 shows the linear regression results for exceeding the speed limit by 10 km/h or more. The model for perceived legitimacy and overt speed cameras predicting exceeding the speed limit by 10 km/h or more was statistically significant, $F(9,1040) = 37.526, p < .001, adjusted R^2 = 0.239$. Meanwhile, the model for perceived legitimacy and covert speed cameras predicting exceeding the speed limit by 10 km/h or more was also statistically significant, $F(9, 1040) = 37.380, p < .001, adjusted R^2 = 0.238$. As above, both regressions had the same significant predictors. Age and gender were significant predictors, indicating young males are significantly more likely to exceed the speed limit by 10 km/h. Use of the enforcement technology was also a significant predictor for both regressions, indicating those who use the technology were significantly more likely to exceed the speed limit by 10 km/h or more. Similar to above, only those who scored high in lawfulness and obligation to obey the law were significantly less likely to exceed the speed limit by 10 km/h or more. Average hours driving, procedural fairness and the legitimacy variables of distributive fairness and camera effectiveness that are specific to overt and covert speed cameras were not significant predictors.

Table 7
Linear regression results for exceeding the speed limit by 1 km/h or more.

Variable	Exceeding the speed limit by 1 km/h or more									
	Overt speed cameras					Covert speed cameras				
	β	Sig.	B	SE	sr ²	β	Sig.	B	SE	sr ²
Age	-0.231	<0.001*	-0.013	0.002	0.045	-0.233	<0.001*	-0.013	0.002	0.046
Gender	-0.029	0.316	-0.067	0.067	0.001	-0.036	0.214	-0.082	0.066	0.001
Average hours driving	0.056	0.036	0.002	0.001	0.003	0.052	0.051	0.002	0.001	0.003
Use of enforcement notification technology	0.100	<0.001*	0.236	0.066	0.009	0.098	<0.001*	0.231	0.066	0.009
Procedural fairness	-0.078	0.046	-0.092	0.046	0.003	-0.039	0.354	-0.046	0.049	0.001
Lawfulness	-0.155	<0.001*	-0.159	0.043	0.009	-0.140	0.001*	-0.144	0.044	0.008
Obligation to obey the law	-0.240	<0.001*	-0.266	0.042	0.028	-0.238	<0.001*	-0.264	0.042	0.027
Distributive fairness	0.065	0.082	0.076	0.044	0.002	0.026	0.554	0.026	0.045	0.000
Camera effectiveness	-0.045	0.136	-0.026	0.018	0.002	-0.071	0.038	-0.043	0.021	0.003

Note. After Bonferroni adjustments, results are considered significant at the 0.025 level.

Table 8
Linear regression results for exceeding the speed limit by 10 km/h or more.

Variable	Exceeding the speed limit by 10 km/h or more									
	Overt speed cameras					Covert speed cameras				
	β	Sig.	B	SE	sr ²	β	Sig.	B	SE	sr ²
Age	-0.106	<0.001*	-0.005	0.001	0.010	-0.106	<0.001*	-0.005	0.001	0.009
Gender	-0.106	<0.001*	-0.186	0.052	0.009	-0.111	<0.001*	-0.195	0.051	0.010
Average hours driving	0.004	0.883	0.000	0.001	0.000	0.004	0.879	0.000	0.001	0.000
Use of enforcement notification technology	0.103	<0.001*	0.186	0.051	0.010	0.104	<0.001*	0.187	0.051	0.010
Procedural fairness	-0.024	0.548	-0.022	0.036	0.000	-0.026	0.544	-0.023	0.038	0.000
Lawfulness	-0.133	0.002*	-0.105	0.034	0.007	-0.138	0.002*	-0.108	0.034	0.007
Obligation to obey the law	-0.281	<0.001*	-0.237	0.033	0.038	-0.287	<0.001*	-0.242	0.033	0.040
Distributive fairness	0.011	0.775	0.010	0.034	0.000	0.021	0.637	0.016	0.035	0.000
Camera effectiveness	-0.038	0.218	-0.017	0.014	0.001	-0.022	0.521	-0.010	0.016	0.000

Note. After Bonferroni adjustments, results are considered significant at the 0.025 level.

4. Discussion

The findings from this study demonstrate the importance of raising perceptions of legitimacy for camera-based speed enforcement. The dimensions of Tankebe's (2012) multidimensional model of legitimacy have been shown to influence compliance by shaping whether individuals view enforcement as appropriate, fair, and justified. Answering RQ1, this study demonstrated that overt speed cameras were perceived as significantly more legitimate than covert ones, specifically in terms of distributive fairness and effectiveness. Nevertheless, only perceptions of lawfulness and obligation to obey the law (but none of the legitimacy variables related to overt or covert speed enforcement) were significant predictors of less frequent speeding behaviour, answering RQ4. These findings highlight the importance of perceptions towards legitimacy of the speeding law in preventing speeding behaviour yet also demonstrate perceived legitimacy towards speed cameras, especially covert cameras need to be increased. Answering RQ3, the use of technologies that display enforcement locations (e.g., Google Maps, Waze) was also found to play a role in this, with those that use the technology having higher perceptions of legitimacy for the speeding law, as well as higher perceptions of effectiveness of covert speed cameras than those that did not use the technology. This indicates the importance of taking into account the use of such technologies in reducing legitimacy of traffic laws and enforcement. Legitimacy is not a secondary concern—it is a foundational condition for voluntary rule-following and sustained behavioral change. As such, decision-makers should be mindful that enforcement strategies do not operate in a vacuum. Low public perceptions of traffic laws and certain enforcement strategies risk undermining the broader system over time. These results recognise that perceived legitimacy is an asset that must be protected to support long-term improvements in road safety behaviour across the community.

Answering RQ2, the present findings reveal that drivers who use punishment avoidance technologies—such as navigation apps or social media alerts—engage in speeding more frequently and are significantly more likely to actively scan for speed cameras compared to those who do not use these tools. These drivers also reported seeing more covert cameras, despite both groups reporting similar exposure to overt cameras. This suggests that third-party technologies are particularly effective at revealing covert enforcement, which would otherwise go unnoticed. Importantly, this type of awareness is distinct from official government sources like roadside signage or public campaigns, which aim to build transparency and legitimacy into enforcement systems. In contrast, technology-mediated awareness can enable selective compliance, as drivers use these tools to manage risk rather than internalise road rules. These findings align with Truelove, Stefanidis, et al. (2023), who found that punishment avoidance technologies can produce mixed deterrence outcomes: on one hand, increasing general deterrence by raising perceived enforcement visibility, but on the other hand, facilitating punishment avoidance and lowering specific deterrence over time. As police officers interviewed in their study noted, such

technologies may contribute to a false sense of certainty about where and when enforcement occurs, leading drivers to offend in areas perceived as “safe.” This duality reinforces the idea that simply increasing awareness is not inherently beneficial; the source and intent behind that awareness matter. Therefore, while these tools might superficially increase driver vigilance, they may simultaneously erode the perceived legitimacy of enforcement, especially if they are used to outsmart the system.

Previous research has also demonstrated that certain elements of procedural justice, such as normality—the perception that decisions are made based on facts rather than bias or personal beliefs—play an important role in shaping young drivers' responses to speed enforcement. Specifically, [Bates et al. \(2016\)](#) found that this dimension was relevant for how young drivers perceived both point-to-point and mobile speed cameras. This suggests that the way enforcement is perceived—not just whether it occurs—can influence how different driver groups engage with road rules. However, in all sets of regression models predicting both low-level speeding (exceeding the speed limit by 1 km/h or more) and higher level speeding (exceeding the speed limit by 10 km/h or more), procedural fairness did not emerge as a significant predictor. This may reflect the more general wording of the measure used in this study or indicate that procedural fairness is less salient for influencing actual speeding behaviour across a broader population.

Instead, the models showed that lawfulness and obligation to obey the law—two broader constructs from the multidimensional legitimacy framework—were consistent and significant predictors of lower engagement in low-level speeding. These findings suggest that while procedural fairness may be particularly influential for certain subgroups, such as younger drivers, broader moral and normative beliefs about the law exert a more consistent influence on behaviour across the general population. This aligns with research on procedural justice, which finds that individuals are more likely to comply with laws not merely due to fear of punishment but because they perceive legal authorities as legitimate and fair ([Tyler, Goff, & MacCoun, 2015](#)). For road safety efforts, this implies that strategies emphasizing the civic and moral value of traffic laws may be more impactful than those focused solely on perceptions of fairness in enforcement. Supporting long-term compliance will likely require not just detection or deterrence, but also efforts to foster internalized respect for legal norms. When this sense of legitimacy is weakened—such as through practices perceived as revenue-driven and with the use of technologies that display enforcement locations—overall effectiveness may be undermined.

The second set of regression models, which examined high-level speeding (exceeding the speed limit by 10 km/h or more), revealed a similar pattern. Younger age and male gender were again significant predictors of increased speeding, reflecting longstanding demographic trends. Additionally, the use of enforcement notification technology remained a significant predictor of more frequent speeding, raising concerns that such tools may facilitate intentional or strategic rule-breaking. Crucially, the broader legitimacy variables—lawfulness and obligation to obey the law—continued to predict reduced high-level speeding, even for more serious infractions. In contrast, more specific perceptions of legitimacy—such as distributive fairness, camera effectiveness, and procedural fairness—did not significantly predict behaviour. These findings suggest that fostering internalized respect for legal norms is more effective for shaping sustained behavioral compliance than focusing solely on attitudes towards specific enforcement mechanisms. This conclusion echoes prior work on procedural justice and legitimacy, which demonstrates that voluntary adherence to laws stems primarily from a belief in the legitimacy of legal authorities and systems, rather than from narrowly perceived fairness in individual encounters ([Tyler et al., 2015](#)). Together, both sets of regression models underscore the central role of internalized legitimacy in reducing both low-level and high-level speeding behaviour.

Overall, the findings from this study highlight the complex relationship between technology use, enforcement visibility, and perceptions of legitimacy in shaping speeding behaviour. While technology can increase drivers' awareness of enforcement, its use to avoid detection raises questions about its impact on long-term compliance. The results suggest that it is not only the presence of enforcement that influences behaviour, but also how the law and enforcement practices are perceived. General legitimacy beliefs—such as viewing the law as morally appropriate and feeling a sense of obligation to comply—were consistently associated with lower levels of speeding. In contrast, perceptions tied to specific enforcement methods, such as fairness or effectiveness of individual cameras, were less influential. These patterns suggest that road safety strategies may benefit from placing greater emphasis on reinforcing broader legitimacy, rather than focusing solely on visibility or enforcement precision. As road enforcement systems continue to incorporate new technologies, maintaining public confidence in the fairness and purpose of enforcement may support more sustainable behaviour change over time.

While this study provided a more in depth understanding of punishment avoidance technologies, enforcement visibility and perceptions of legitimacy for speeding, there are a number of limitations that need to be acknowledged. First, this study consisted of cross-sectional self-report measures. Future studies should consider longitudinal studies to determine if there are any changes in these perceptions over time. More objective measures of speed should also be considered in future research. Further, while participants were recruited from across Australia and involved a good cross-section of drivers across metropolitan, regional and rural areas, this does limit generalisability to other countries, which should also be considered in future research. In addition, this study did not include income level of participants. Fines associated with speed infringements may have differing effects on low-income compared to high-income drivers, which may also impact perceived legitimacy for speed enforcement. This should be considered when interpreting the results and should be included in future research. This study also did not include drivers' exposure to speed cameras (e.g., if they pass them frequently near their house and/or workplace), which should be considered in future research as exposure may also impact perceived legitimacy.

The population of participants have similarities with the general Australian driving population. The mean age of participants from this study is 48.8 years (SD = 20.46), while the census data from the Australian Bureau of Statistics ([ABS, 2021](#)) showed the mean age of Australians was approximately 38 years. While the mean age of drivers is unavailable, considering people can only obtain a learner licence at 16 and a provisional licence at 17, the mean age of drivers is likely to be closer to the mean age of participants in this study. Further, this study included 56.5% males and 43.5% females. Australia's population has 50.7% females and 49.3% males ([ABS, 2021](#)), meaning there is some overrepresentation of males in this study, which should be considered when interpreting the findings.

5. Conclusion

This study explored how perceptions of legitimacy—framed through Tankebe's multidimensional model—relate to different types of speed camera enforcement and how these perceptions differ based on drivers' use of technology that notifies them of enforcement locations. The findings show that overt speed cameras are viewed as more fair and effective than covert ones, and that drivers who use notification technologies report more frequent speeding and greater awareness of covert cameras. Across both low- and high-level speeding models, the strongest predictors of reduced speeding were the broader legitimacy dimensions of lawfulness and obligation to obey the law, rather than perceptions tied to specific enforcement tools. These results highlight the importance of reinforcing the moral grounding of traffic laws and fostering internalized motivation to comply. As road safety interventions increasingly intersect with digital tools, efforts to sustain and build legitimacy should remain a priority. Doing so may support more durable compliance and strengthen the long-term effectiveness of speed enforcement strategies.

CRedit authorship contribution statement

Verity Truelove: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Conceptualization.

Funding

This work was funded with assistance from the ACT Government under the ACT Road Safety Fund Community Grant Program. Additional funding for first author writing of the manuscript was provided by the MAIC/University of the Sunshine Coast Road Safety Research Collaboration Grant.

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.

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