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# Road rule enforcement and where to find it: An investigation of applications used to avoid detection when violating traffic rules

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A B S T R A C T

*Introduction:* One of the primary countermeasures in place to prevent road rule violations is legal enforcement, yet there are numerous applications that can undermine such efforts by notifying drivers of enforcement locations. However, the capabilities of these applications and how they can impact offending behavior is currently unknown. *Method:* Two studies were conducted to understand which of these applications are being used by drivers and how these applications are impacting road rule violations. Study 1 consisted of a content analysis that involved searching the Google Play Store and Apple iTunes Store for applications that could be used to avoid road rule violations using pre-determined keywords. Meanwhile, Study 2 consisted of 468 licensed Australian drivers (54.5% males) over the age of 17 years ($M_{age}$ = 35 years) who completed a survey. *Results:* A total of 73 applications were identified for Study 1, with most of the applications displaying speed camera locations. It was found that applications that notify drivers of traffic enforcement locations are widely prevalent, can be used on a variety of interfaces and include numerous additional features. Study 2 found that those who use the applications were more willing to speed than those who do not use the applications, while there was no difference in phone use while driving between those who do and do not use the applications. *Practical Applications*: The findings have important implications for stakeholders, policy, and future research. For example, it is suggested that specific functions of these applications need to be regulated to reduce road rule violations and crash risk. Meanwhile, enforcement initiatives need to evolve at a faster rate to keep up to date with the changing technology that can undermine them.



## 1. Introduction

Engagement in road rule violations have consistently been found to increase crash and subsequent severe trauma risk. Speeding has been associated with an increased risk of crashing and severity of injuries following a crash, while impairment due to drunk or drug driving also significantly increases the likelihood of crashing (Dingus et al., 2016; Elvik, 2013; Romano et al., 2013). Mobile phone use is also linked with increased crash risk (Leung et al., 2012), due to increased lane variation, reductions in speed, and slower reaction times when a driver's attention is removed from the road (Drews et al., 2009; Li et al., 2020; Onate-Vega et al., 2020; Vlakveld et al., 2021). These risky behaviors continue to be highly prevalent in many jurisdictions around the world. As reported by the World Health Organisation (2022), road crashes are attributed to over a million fatalities every year and are one of the leading causes of death across the world. Mobile phone and smartphone popularity has significantly increased in recent years, with over 80% of the world having access to these devices due to their potential to support internet connection, communication, and entertainment services within seconds (O'Dea, 2022). However, the increasing popularity of these devices have also been shown to correlate with increasing engagement in mobile phone use while driving (Oviedo-Trespalacios et al., 2019a; Rahmillah et al., 2023). The prevalence and risk of these behaviors present a large concern for road safety.

One of the primary strategies used to prevent road rule violations is legal enforcement; yet ironically, there are mobile phone applications that can be used to notify drivers of these enforcement locations. This means that drivers may illegally be using their phone to avoid being caught for this behavior and other road rule violations. Prior to phone applications, drivers would purchase speed radars that could be used to detect law enforcement. Drivers using speed radars were associated to have increased crashes and speeding habits (Rudin-Brown & Cornelissen, 2012). Expectedly,

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these devices are now illegal in Australia and can result in large infringements if found in vehicles (Queensland Government, 2023). Yet in many countries worldwide, phone applications that show the locations of police enforcement are legal and not susceptible to legal action. However, countries such as France, Germany, and Switzerland have banned the use of these applications, and drivers found to be using these applications can receive large infringements and may even have their vehicle confiscated (Dent, 2019; Get To Text, 2022). While there are numerous legal enforcement initiatives in place to capture road rule violations such as speed cameras, mobile phone detection cameras, random breath testing [RBT], roadside drug testing [RDT], as well as direct police enforcement, it can be suggested that applications used to avoid detection are evolving at a faster rate. Yet, this is not surprising given previous strategies drivers (and the general population) have used to avoid detection for road rule violations. For example, prior to social media, drivers would flash their headlights to warn drivers of upcoming police and speed enforcement. In more recent times, Facebook pages/groups have been created that post up-to-date locations of enforcement sites. Therefore, this research provides a much-needed investigation into the available smartphone applications that have the ability to notify drivers of enforcement locations to determine the prevalence and features of these applications. Further, this research also examines if the use of these applications impacts offending behavior.

Mobile phone applications that show the location of police enforcement of road rules are readily available on the Google Play store and Apple iTunes store. The affordance of these applications would vary greatly depending on the individual. Affordances refer to the way an individual uses and interacts with a system (Gaver, 1991). When it comes to technology such as phone applications, how the application is afforded relates to one's own perceptions toward the usability and usefulness of the system (Blin, 2016). For example, the affordance given to the applications is likely to differ if a driver is closer to losing their license because they have received previous traffic infringements, compared to those who have not received any infringements in the past (Gaver, 1991). There are various possible effects that such applications may have on perceptions and behavior related to road rule violations, as well as enforcement of these behaviors. First, it is possible that exposure to enforcement initiatives via the applications may promote general deterrence. General deterrence involves the proposition that the general public is deterred from committing an offense provided they believe there is a high perceived certainty of being caught and the punishment would be severe and delivered swiftly (Beccaria, 1764/2007; Bentham 1780/1970). It can be suggested that drivers who use the applications that notify them of enforcement locations would be aware of more enforcement operations than those who do not use these applications. Therefore, it is possible that some of these application users may have a higher perceived certainty of being caught for violating road rules than non-users.

Alternatively, the use of the applications may instead decrease perceptions of apprehension certainty by increasing perceptions that they can avoid being detected and subsequently punished for the offense (Stafford & Warr, 1993). Previous road safety literature has demonstrated that punishment avoidance is a leading predictor of continued engagement in offending behavior (e.g., Fleiter & Barry, 2005; Ochenasek et al., 2021; Szogi et al., 2017; Truelove et al., 2019). The way in which drivers may avoid being caught for a traffic offense can depend on whether they are violating a transient or fixed rule. Transient road rules are those that can be engaged in multiple times during a trip (e.g., using a phone while driving and speeding), while fixed road rule violations are those that occur throughout the entire trip (e.g., drunk driving and drug driving; Scott-Parker et al., 2012). Drivers who are engaging in transient road rules may simply stop this behavior for a duration of time while passing known enforcement locations they are notified of via the application. As this is not an option for fixed road rule violations, it is possible that drivers who are violating these rules instead change their route to avoid detection. Alternatively, drivers may check these applications before they drive to determine if it looks like enforcement operations may be present on their route and make a decision as to whether or not they will take the journey at all. This is supported by previous research that examined drug driving on Facebook pages, indicating that a number of drug takers used police location pages to avoid being detected with any drugs in their system while driving (Mills et al., 2022). As such, while knowing enforcement locations has the potential to prevent engagement in illegal behavior at certain times, or increase the general deterrent effect, it can also enable drivers to engage in the behaviors without being caught. A gap in the literature is that we do not fully understand the capabilities of these applications and how they can compromise the effectiveness of enforcement using empirical data.

It is necessary to understand the capabilities of these applications to proactively identify other risks. Oviedo-Trespalacios and Watson (2021) highlighted that these applications not only reduce perceptions of detection but could also result in distracted driving itself, as they often request motorists to validate the information displayed. It should also be noted that there are a multitude of ways in which drivers can use these applications on their phone while driving, all of which can adversely affect driving safety. For example, a common method can involve holding the phone in the hand to use the applications while driving. Indeed, hand-held phone use has been demonstrated to significantly reduce driver performance (e.g., delay responses to hazards) and increase the likelihood of crashing (Caird et al., 2014; Caird et al., 2018). Further, some applications may provide unexpected audio information that may interrupt the driving tasks. Interruptions can compromise safe driving if they occur in situations where attention demands may be high (Hinton et al., 2022). However, research has shown that auditory interactions with a mobile phone can affect attentional capacity and driver behavior. For example, the use of hands-free functions/voice interactions has been shown to increase response latencies and variability in lane positioning compared to not using a phone while driving (Simmons, Caird, & Steel, 2017). Meanwhile, in more advanced vehicles, the in-vehicle infotainment systems, such as those that are equipped with Apple CarPlay or Android Auto, have the potential to integrate phone applications into the system, meaning drivers can interact with the application via the vehicles touch screen. Of concern, it has recently been identified that interacting with Apple CarPlay or Android Auto has detrimental effects on driving, in some cases these effects are worse than the impact of texting while driving (Ramnath et al., 2020; Oviedo-Trespalacios et al., 2019b).

To date, there are numerous factors associated with the capabilities of these applications that have yet to be assessed. As the use of these applications while driving can be a distraction, it is necessary to understand how drivers can interact with them and the various functions that may be available to the user. Further, the extent to which these applications facilitate punishment avoidance is unclear. Identifying the number of applications available to users, and the different types of traffic enforcement operations that are displayed on the applications, will provide a clearer picture of the extent to which these applications may promote exposure to enforcement. The paper has two aims. The first aim seeks to understand the features of applications designed to avoid law enforcement by means of a content analysis. The specific objectives of the content analysis include (a) identify the number of punishment avoidance technologies/applications available to smartphone users; (b) identify ways in which users can interact with these smartphone applications; and (c) identify features that can be used to facilitate punishment avoidance within these smartphone applications. Importantly, the extent to which the applications impact behavior is also dependent on how they are used. Therefore, the second aim is to understand what applications are being used among a sample of drivers and if users of these applications are more likely to engage in road rule violations than non-users. The paper is divided into two studies seeking to address these two aims.

## 2. Study 1 method

A content analysis on smartphone applications that can be used for the avoidance of detection cameras and traffic law enforcement was conducted. Ethics approval was granted for this project by the University of the Sunshine Coast Human Research Ethics Committee (S211553).

### 2.1. Search criteria and strategy

MN conducted preliminary searches on the Google Play Store and Apple iTunes Store to identify key words that would provide the most accurate and extensive search results. Keywords were reviewed by VT and KS prior to the search and included speed, radar detection, speed radar, and police camera for both the Apple iTunes store and the Google Play Store. While initial search terms were used to include words related to drug driving detection, drunk driving detection, mobile phone use while driving detection, as well as broader police detection, it became evident that there were no applications that currently advertised these functions. Instead, the applications were only advertised to detect speed cameras and police enforcement. Searches were conducted by MN between December 2021 and January 2022, and the name of relevant smartphone applications were copied into a spreadsheet. Inclusion criteria for applications include those that either advertised: (a) police avoidance technology or (b) speed cameras/traps. A total of 192 applications were extracted from the Google Play Store and 54 titles from the Apple iTunes Store. An updated search was conducted in August 2022, and an additional eight applications were found from a separate search across the two application stores. After removing duplicates, applications that were not in English, and applications that became unavailable after title extraction ($n = 33$), 50 titles remained from the Google Play Store and 31 remained from the Apple iTunes Store, respectively. Eight titles were duplicates across the two application stores. Refer to Fig. 1 for a visual representation of the search strategy.

### 2.2. Coding

The coding sheet was created on an Excel spreadsheet and developed by VT and OO in order to extract relevant information from the smartphone applications. Codes were developed using an iterative process, where an initial 10 applications were reviewed to ensure codes were able to capture the key functions specific to these types of applications. The coding of characteristics of the applications was guided by previous research (Oviedo-Trespalacios et al., 2019c; Robinson et al., 2018), and included the current version of the application, number of installations and reviews, as well as whether the application cost anything, involved in app-purchases or included advertisements. Since the iTunes store also outlined the different devices that the applications were available on, this information was also coded to further demonstrates the various ways drivers can use these applications. Further, considering the accuracy of information related to traffic enforcement can depend on how the application obtains data (e.g., via users or from their own data), the data source was also included.

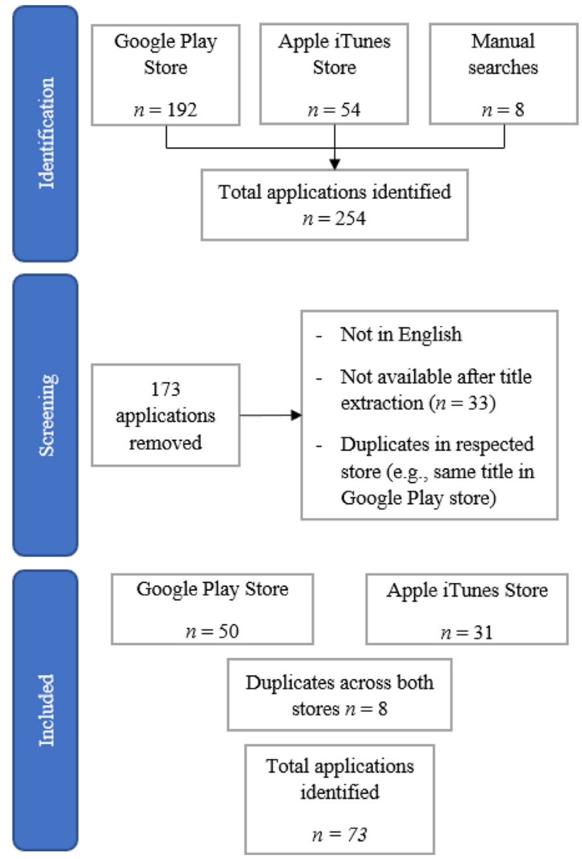


**Fig. 1.** Search strategy for punishment avoidance applications.

The next section was coded based on functions that enable users to avoid being detected for a traffic offense, as well as any other functions of the application related to driving, the ways the user can interact with the application and how the application communicates with the user. These codes were developed by the researchers and informed by literature (e.g., Oviedo-Trespalacios et al., 2019c; Stafford & Warr, 1993). Note that all data extracted were from the description provided by the applications on the stores.

## 3. Study 1 results

### 3.1. Characteristics of punishment avoidance technologies/applications

Overall, 73 applications were identified that are primarily used for avoiding speed detection cameras and police enforcement. The main characteristics of the applications are presented in Table 1. From the 50 Google Play store applications, only 13 applications had over 1,000,000 installations, with the majority of applications having less than 10,000 installations. Note that Apple iTunes stores does not disclose the number of installations. Data are collected for the applications by either (a) users providing real-time information while on the road, or (b) data comes directly from the application, either from other data bases (i.e., Google maps), information presented on transport/police departments, or information collected through social media posts (i.e., police location Facebook pages/-groups). Across the two application stores, 32 applications (44%) collect data from users, 33 applications (45%) provide their own data, and 14 applications (19%) use a combination of the methods.

**Table 1**
Characteristics of police avoidance technology smartphone applications on google play store & apple iTunes store.

**Google Play Store**

| Smartphone Application | Version | Number of Installations[a] | In-app purchases/ adverts | Reviews | Data Source[b] |
|---|---|---|---|---|---|
| Alert Speed, Police, Camera & Work 2k20 | 1.5 | 10,000+ | Ads | - | DA; UB |
| AntiRadar | 1.0.2 | 10,000+ | - | - | DA |
| AutoMate – Car Dashboard: Driv | 2.3.2-minAPi21 | 1,000,000+ | In-app purchases | 11,200+ | UD |
| CamSam - Speed Camera Alerts | 3.7.6 | 5,000,000+ | - | 57,000+ | UB |
| Check Out: Police, Camera, Work & Speed | 10.3 | 10,000+ | Ads | - | UB |
| Chicago Speed Camera Alerts | 8.6 | 10,000+ | Both | - | DA |
| Cobra iRadar® | 5.1.70 | 500,000+ | Both | 5,000+ | DA; UB |
| Escort Live Radar | 3.1.70 | 500,000+ | Both | 10,000+ | DA; UB |
| Google Maps | 11.42.0802 | 10,000,000,000+ | - | 16,000,000 + | UB |
| Gps speedometer and odometer | 1 | 10,000+ | Ads | - | DA |
| Hi Speed Radar,Camera, Blitzi, Traffic, Alert 2k21 | 1.4.0 | 500+ | - | - | UB |
| Highway Radar | 2.6 | 10,000+ | - | - | DA |
| KoDin Maps online police map, radar detector, chat | 1.0.7 | 10,000+ | Both | - | UB |
| MapcamDroid Radar detector | 3.83.1130 | 1,000,000+ | Both | 45,000+ | UD |
| NSW Radar Alert | 3.7 | 500+ | Both | - | DA |
| piPOIAlert - Speed Camera | 1.4.2-r3 | 10,000+ | - | - | DA |
| POIbase speed camera warner | 7.4.1 | 100,000+ | In-app purchases | - | DA |
| Police Camera Blitz & Detector | 1.18.2 | 10,000+ | Ads | - | DA; UB |
| Police Detector, Radar, Blitz Camera & Alert | 1.9 | 100,000+ | Ads | 1,000+ | DA; UB |
| Police Speed & Traffic Camera Radar & Detector | 2.3.1 | 100,000+ | Ads | 3,000+ | UB |
| Radar & Police Detector: Camera, Blitz, Traffic | 1.11.9 | 50,000+ | Ads | 1,000+ | UB |
| Radar Beep - Radar Detector | 3.0.0 | 1,000,000+ | Both | 28,000+ | DA |
| Radar GO-X: HUD, Navigation | 2.5 | 1,000,000+ | Both | 11,000+ | DA |
| Radar Maps, Speed Cameras, Map Navigations | 1 | 500+ | Ads | - | DA |
| Radar Trap | 4.2 | 500,000+ | Ads | 3,000+ | UB |
| Radar, HUD, Map, Speed Camera | 1.1 | 100+ | Ads | - | DA |
| Radarbot Speed Camera Detector | Varies with device | 10,000,000+ | Both | 364,000+ | DA; UB |
| Radardroid Lite International | 3.75 | 5,000,000+ | Ads | 33,000+ | DA |
| Radardroid Pro | 3.75 | 50,000+ | - | 9,000+ | DA |
| Speed Adviser | 1.21.2 | 10,000+ | - | 220 | DA |
| Speed Camera (Brisbane) | 8.6 | 10,000+ | Both | 100+ | DA |
| Speed Camera (Melbourne) | 8.7 | 10,000+ | Both | 90+ | DA |
| Speed Camera (Sydney) | 8.6 | 10,000+ | Both | 30+ | DA |
| Speed Radar Detector - Police | 1.1.6 | 100,000+ | Both | 550+ | DA |
| Speed Camera Detector: GPS Map | 1.26 | 100,000+ | Ads | 2,000+ | DA; UB |
| Speed camera map:Radar detector & speedometer | 1.0.5 | 10,000+ | Both | - | DA |
| Speed Camera Radar | 3.1.40 | 10,000,000+ | Ads | 68,000+ | UB |
| Speed Camera Radar (Light) | 2.1.27 | 50,000+ | Both | - | UB |
| Speed Camera Radar (PRO) | 3.1.41 | 50,000+ | - | 1,000+ | UB |
| Speed Camera: Radar detector | 1.5 | 10,000+ | Ads | - | UB |
| Speed camera: radar, alerts | 1.0.9 | 50,000+ | Ads | - | UB |
| Speed Camera: Radarbot & Radar | 1.9 | 1,000+ | Ads | - | UB |
| Speed cameras in Ukraine | 2.4 | 50,000+ | Both | - | DA |
| Speed Cameras Radar | 3.6 | 1,000,000+ | Both | 11,000+ | UB |
| Speed Cameras Radar NAVIGATOR | 1.4.9 | 500,000+ | Both | 4,000+ | UB |
| Speed Detector & Camera Birtz Radar, Traffic 2k21 | 1.1.4 | 1,000+ | - | - | DA; UB |
| Sygic GPS Navigation & Maps | 22.2.5–2090 | 50,000,000+ | In-app purchases | 1,800,000+ | UB |
| TomTom AmiGO - GPS Navigation | 8.237.0 | 5,000,000+ | - | 100,000+ | DA; UB |
| Watch out: Police Camera, Speed, Work | 1.4 | 1,000+ | Ads | - | UB |
| Waze - GPS, Maps, Traffic Alerts & Live Navigation | 4.78.0.2 | 100,000,000+ | Ads | 8,400,000+ | UB |

**Apple iTunes Store**

| Smartphone Application | Version | Device availability | | | | | In-app purchases/ adverts | Reviews | Data Source[b] |
|---|---|---|---|---|---|---|---|---|---|
| | | iPhone | iPad | iPod | Mac | Watch | | | |
| Aman - Speed Radar | 1.2 | X | X | X | X | - | - | - | UB |
| Apple Maps | UD | X | X | X | X | X | - | 13,000+ | UB |
| Catchit Road - Speed Control | 1.5 | X | X | X | X | - | Both | 11 | DA; UB |
| Cobra iRadar | 5.1.29 | X | - | X | - | - | Both | - | DA; UB |
| CoDrivers - GPS Driving Assistant | 1.9 | X | - | X | - | - | - | 2 | UB |
| Escort Live Radar | 3.1.27 | X | - | X | X | - | Both | - | DA; UB |
| Glob - GPS, Traffic and radars | 1.0.2 | X | X | X | X | - | - | 17 | UB |
| Google Maps | 6.35 | X | X | X | - | - | - | 4,800,000+ | UB |
| I SpeedCam Free (Speed Camera Detector) | 2.4.0 | X | - | X | X | - | Both | 3 | UB |
| KAZA LIVE Radar Warning | 3.2 | X | X | X | X | - | Both | 3 | DA; UB |
| LuxSpeed | 3.1.5 | X | X | X | - | - | Both | 1,800+ | UB |
| NSW Radar Alert | 3.8 | X | X | X | - | - | Both | - | DA |
| PhantomALERT | 5.2.1 | X | X | X | X | - | Both | 57 | UB |
| Radar Reminder South Australia | 6.1 | X | - | X | - | - | Both | 5 | DA |

**Table 1** (*continued*)

| Google Play Store | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Smartphone Application** | **Version** | **Number of Installations[a]** | | | | | **In-app purchases/ adverts** | **Reviews** | **Data Source[b]** |
| RadarAll: Speedcam detector | 2.0.2 | X | X | X | X | X | Both | 11 | DA |
| Skip Cams: Cam detector | 16.0.2 | X | X | X | - | X | Both | 3 | DA[c] |
| South Australian Radar Alert | 5 | X | X | X | - | - | Both | 13 | DA |
| Speed Adviser | 1.23.3 | X | - | - | X | - | - | 68 | DA |
| Speed Camera Radar Detector | 2.3 | X | - | X | X | - | Both | 1 | UB |
| Speed cameras and red lights | 1.13 | X | X | X | - | X | Both | 311 | UB |
| Speed Trap Plus | 3.2 | X | X | X | X | X | Both | 145 | DA |
| Speeding Alert - Calgary | 1.4.1 | X | - | X | - | - | Both | 8 | DA |
| Sygic GPS Navigation & Maps | 22.2.2 | X | X | X | - | - | In-app purchases | 47,000+ | UB |
| TomTom AmiGO - GPS & Warnings | 8.240.0 | X | - | X | X | - | - | - | DA; UB |
| TomTom GO navigation & traffic | 2.8.2 | X | - | X | - | - | Both | 772 | DA |
| UAE Cam Radar | 2 | X | X | X | X | - | - | - | DA |
| VIC Radar Alert | 3.8 | X | X | X | - | - | Both | 1 | DA |
| Victorian Speed Camera Alerts | - | X | - | X | - | - | - | 4 | DA |
| WA Speed Camera Alerts | 1.01 | X | - | X | - | - | - | - | DA |
| WatchOUT AI | 1.1 | X | - | X | - | - | - | - | UB |
| Waze Navigation & Live Traffic | 4.79 | X | X | X | - | - | - | 45,900+ | UB |

*Note.* [a]Information not available on the Apple iTunes Store. [b]How/where the application gathers information: User-based information (UB); Data from the application (DA); Undisclosed (UD). [c]Users can contact the application with new camera locations.

Note that two applications (3%) did not disclose or provide enough details to collect this information. All applications across both stores were free to download, with the exception of two applications including Speed Camera Radar (PRO) (AUD$2.99) and UAE Cam Radar (AUD$4.49). It should also be noted that one application – Speed Advisor - was created by a government organization, while all other applications were created privately. Specifically, Speed Advisor was created by the New South Wales (NSW), Australia government and notifies drivers when they are going over the speed limit, as well as when they are entering a mobile speed camera location in NSW.

### *3.2. Punishment avoidance features within these applications*

All applications could be used for punishment avoidance by either: (a) notifying road users of speed cameras (i.e., fixed/mobile/both) (100%), and/or (b) users having the ability to mark locations of detection cameras (53%) and/or police locations (18%) on the application. The majority of applications notify users of their current speed (74%) and the speed limit within their location (74%). In addition, 41% of applications alert drivers when driving over the speed limit, which could be considered a positive feature of these applications. Only a small percentage (5%) of applications had the feature to reroute drivers to avoid law enforcement (e.g., speed/red light cameras). Specific details can be found in Table 2.

### *3.3. Other features/functions facilitated by these applications*

Overall, 70% of applications can communicate to the driver both visually and audibly, while 30% of applications can communicate visually only. Limited applications can be integrated within the vehicle's infotainment system (14%), while other applications can be used simultaneously with music applications (i.e., Spotify, Apple music) (34%), or other applications such as Facebook messenger, internet browsers, or social media (36%). It should be noted that 44 applications did not specify the ability to run simultaneously with the vehicle or other applications in the description, and thus it is possible that some applications may have the feature despite not disclosing the information. In addition, just over half (51%) of the applications can be used for navigation. Additional features of these applications include notifying drivers of upcoming traffic conditions (60%) and roadworks (51%), with a minority of the applications alerting drivers of hazards on the road (e.g., debris, broken down vehicle) (29%). Finally, 22 applications allow users to interact with each other on the application, such as rating other users marked locations/hazards (11%), messaging or asking other users for help (12%), or sharing images and videos to other users (7%). Specific application features and functions can be found in Table 3. A full summary of the content analysis and smartphone application features is presented in Table 4.

## 4. Study 2 method

While Study 1 provided an overview of the current applications that notify drivers of traffic enforcement locations, it is necessary to also understand how drivers are using these applications. Therefore, a cross-sectional survey was utilized for Study 2 to address the following aims:

1. Identify what applications are being used among a sample of drivers.
2. Identify if users of these applications are more likely to engage in road rule violations than non-users.

As Study 1 identified that the applications primarily advertised displaying speed enforcement locations, Study 2 focused specifically on speeding. Further, as these applications can be used while driving, engagement in illegal phone use while driving (i.e., handheld phone use) was also examined in Study 2. These are the two main behaviors targeted by automated enforcement in Australia where the study was being conducted.

### *4.1. Participants*

A total of 468 participated in a cross-sectional survey concerning applications that show the locations of road rule enforcement activities. The participants held a valid drivers license in Australia and were required to be aged 17 or older ($M$ = 35.01; $SD$ = 19.13). Most of the participants were males (54.5%; $n$ = 255), followed by females (42.5%; $n$ = 199) and other (3%; $n$ = 14). Participants were recruited using social media posts (e.g., Facebook and Twitter), which advertised to the general population (77%). In addition, the study was advertised on QUT SONA system (a web-based research recruitment management system), where first year psychology

**Table 2**
Direct punishment avoidance functions on smartphone applications.

| Smartphone application | Punishment avoidance features | | | | Marking locations on map (user-based) | | | Option to choose route with fewer radars |
|---|---|---|---|---|---|---|---|---|
| | Type of speed cameras (fixed/mobile/both) | Warn the user when driving over the speed | Notify user of speed limits | Speedometer | Speed cameras | Police | Red light cameras | |
| Alert Speed, Police, Camera & Work 2k20 | Both | - | X | X | X | - | - | - |
| Aman - Speed Radar | Both | - | - | X | X | - | - | - |
| AntiRadar | Fixed | X | X | X | - | - | - | - |
| Apple Maps | Both | - | X | - | X | - | - | - |
| AutoMate – Car Dashboard: Driv | Both | X | X | X | X | - | X | - |
| CamSam - Speed Camera Alerts | Both | - | X | X | X | - | X | - |
| Catchit Road - Speed Control | Both | X | X | X | - | - | - | - |
| Check Out: Police, Camera, Work & Speed | Both | X | X | - | X | - | - | - |
| Chicago Speed Camera Alerts | Both | - | - | - | - | - | - | - |
| Cobra iRadar®[a] | Both | X | X | X | X | - | X | - |
| CoDrivers - GPS Driving Assistant | Both | - | - | X | - | - | - | - |
| Escort Live Radar[a] | Both | X | X | X | X | - | X | - |
| Glob - GPS, Traffic and radars | Both | - | X | X | X | X | - | - |
| Google Maps[a] | Both | X | X | X | X | - | - | - |
| Gps speedometer and odometer | Both | - | X | X | - | - | - | - |
| Hi Speed Radar,Camera, Blitzi, Traffic, Alert 2k21 | Both | X | X | - | X | X | - | - |
| Highway Radar | Both | - | X | X | - | - | - | - |
| I SpeedCam Free (Speed Camera Detector) | Both | - | X | X | X | X | - | - |
| KAZA LIVE Radar Warning | Both | - | X | X | X | - | - | - |
| KoDin Maps online police map, radar detector, chat | Both | - | - | - | X | X | - | - |
| LuxSpeed | Both | - | - | - | X | X | - | - |
| MapcamDroid Radar detector | Both | - | X | X | - | - | - | - |
| NSW Radar Alert[a] | Both | - | - | - | - | - | - | - |
| PhantomALERT | Both | - | - | - | X | X | - | - |
| piPOIAlert - Speed Camera | Both | - | - | - | - | - | - | - |
| POIbase speed camera warner | Both | - | X | X | - | - | - | - |
| Police Camera Blitz & Detector | Both | - | X | X | X | X | - | - |
| Police Detector, Radar, Blitz Camera & Alert | Both | X | X | X | X | X | - | - |
| Police Speed & Traffic Camera Radar & Detector | Both | - | X | X | X | - | - | - |
| Radar & Police Detector: Camera, Blitz, Traffic | Both | X | X | X | X | - | - | - |
| Radar Beep - Radar Detector | Both | - | X | X | - | - | - | - |
| Radar GO-X: HUD, Navigation | Both | - | X | X | - | - | - | - |
| Radar Maps, Speed Cameras, Map Navigations | Both | X | X | - | - | - | - | - |
| Radar Reminder South Australia | Both | - | - | X | - | - | - | - |
| Radar Trap | Both | - | - | X | X | - | - | - |
| Radar, HUD, Map, Speed Camera | Both | - | X | X | - | - | - | - |
| RadarAll: Speedcam detector | Fixed | X | X | X | - | - | - | - |
| Radarbot Speed Camera Detector | Both | X | X | X | - | - | - | X |
| Radardroid Lite International | Both | - | X | X | - | - | - | - |

**Table 2** (*continued*)

| Smartphone application | Punishment avoidance features | | | | Marking locations on map (user-based) | | | Option to choose route with fewer radars |
|---|---|---|---|---|---|---|---|---|
| | Type of speed cameras (fixed/mobile/both) | Warn the user when driving over the speed | Notify user of speed limits | Speedometer | Speed cameras | Police | Red light cameras | |
| Radardroid Pro | Both | - | X | X | - | - | - | - |
| Skip Cams: Cam detector | Both | X | X | X | - | - | - | - |
| South Australian Radar Alert | Both | - | - | - | - | - | - | - |
| Speed Adviser | Mobile | X | X | - | - | - | - | - |
| Speed Camera (Brisbane) | Both | X | X | X | - | - | - | - |
| Speed Camera (Melbourne) | Both | X | X | X | - | - | - | - |
| Speed Camera (Sydney) | Both | X | X | X | - | - | - | - |
| Speed Radar Detector - Police | Both | X | X | X | - | - | - | X |
| Speed Camera Detector: GPS Map | Both | X | - | X | X | - | - | - |
| Speed camera map:Radar detector & speedometer | Both | X | X | X | - | - | - | - |
| Speed Camera Radar | Both | - | X | X | X | - | X | - |
| Speed Camera Radar (Light) | Both | - | - | X | X | - | X | - |
| Speed Camera Radar (PRO) | Both | - | X | X | X | - | - | - |
| Speed Camera Radar Detector | Both | - | X | X | X | - | - | - |
| Speed Camera: Radar detector | Both | - | X | X | X | X | - | X |
| Speed camera: radar, alerts | Both | X | X | X | X | X | - | - |
| Speed Camera: Radarbot & Radar | Both | X | - | X | X | X | - | - |
| Speed cameras and red lights | Both | X | X | X | X | - | - | - |
| Speed cameras in Ukraine | Both | - | X | X | - | - | - | - |
| Speed Cameras Radar | Both | X | X | X | X | - | - | - |
| Speed Cameras Radar NAVIGATOR | Both | X | X | X | X | - | - | - |
| Speed Detector & Camera Birtz Radar, Traffic 2k21 | Both | - | X | - | X | X | - | - |
| Speed Trap Plus | Both | - | X | X | - | - | - | - |
| Speeding Alert - Calgary | Both | - | - | - | X | - | - | - |
| Sygic GPS Navigation & Maps[a] | Both | X | X | X | X | - | - | - |
| TomTom AmiGO - GPS Navigation[b] | Both | X | X | X | X | - | - | X |
| TomTom GO navigation & traffic | Both | X | X | X | - | - | - | - |
| UAE Cam Radar | Both | - | - | - | - | - | - | - |
| VIC Radar Alert | Both | - | - | - | - | - | - | - |
| Victorian Speed Camera Alerts | Both | - | - | - | - | - | - | - |
| WA Speed Camera Alerts | Both | - | - | - | - | - | - | - |
| Watch out: Police Camera, Speed, Work | Both | - | X | X | X | X | X | - |
| WatchOUT AI | Both | - | X | - | X | - | - | - |
| Waze Navigation & Live Traffic[c] | Both | X | X | X | X | - | - | - |

*Note.* [a]Duplicate application. [b]Duplicate application, also known as TomTom AmiGO - GPS & Warnings on Apple iTunes. [c]Duplicate application, also known as Waze Navigation & Live Traffic on Apple iTunes. UD = Undisclosed.

students (23%) were also given the option to receive credit points toward their overall subject grade. Participants who did not complete the study for course credit had the option to enter a prize draw (five $100 food vouchers). Data were collected from January 2022 to September 2022. The survey was about the impact of deterrence on risky driving behavior (as part of a larger project), but only items relevant to phone applications were reported in the current study.

### 4.2. Materials

The questions included demographics such as age and gender. Regarding the applications, participants were also asked if they currently have phone applications that share the locations of police enforcement operations (cameras and police checkpoints) (Yes or No). If the participants said yes, they were asked to specify the type of application that they used. Four options were provided: Apple

**Table 3**
Other functions on smartphone applications.

| Smartphone application | Simultaneously run with apps/vehicle[a] | | | Communication of application (audio/visual/ both) | Navigation | Notify of road conditions | | | Interaction with other users | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Integrate with vehicle | Music | Other apps | | | Roadworks | Traffic | Hazards (e.g., pot holes) | Rate marked locations/hazards | Message/ ask for help | Share images/ videos/ alerts |
| Alert Speed, Police, Camera & Work 2k20 | - | - | X | Visual | X | X | X | - | - | X | - |
| Aman - Speed Radar | - | - | - | Both | - | - | - | - | - | - | - |
| AntiRadar | - | - | - | Both | - | - | - | - | - | - | - |
| Apple Maps | X | X | X | Both | X | - | X | X | - | - | - |
| AutoMate – Car Dashboard: Driv | X | X | X | Both | X | - | X | - | - | - | - |
| CamSam - Speed Camera Alerts | - | - | - | Both | - | - | - | X | - | - | - |
| Catchit Road - Speed Control | - | - | - | Both | X | X | X | - | - | - | - |
| Check Out: Police, Camera, Work & Speed | - | X | X | Both | X | X | X | - | - | X | - |
| Chicago Speed Camera Alerts | - | - | - | Visual | - | - | - | - | - | - | - |
| Cobra iRadar®[b] | - | - | - | Visual | X | X | X | X | - | - | X |
| CoDrivers - GPS Driving Assistant | - | - | - | Visual | - | X | X | X | - | - | - |
| Escort Live Radar[b] | - | - | - | Both | X | X | X | X | - | - | X |
| Glob - GPS, Traffic and radars | - | - | - | Both | X | X | X | X | - | - | X |
| Google Maps[b] | X | X | X | Both | X | X | X | X | - | - | - |
| Gps speedometer and odometer | - | - | - | Visual | - | - | - | - | - | - | - |
| Hi Speed Radar, Camera, Blitzi, Traffic, Alert 2k21 | - | - | - | Visual | X | X | X | - | - | - | - |
| Highway Radar | - | - | - | Both | - | - | X | X | - | - | - |
| I SpeedCam Free (Speed Camera Detector) | - | - | - | Both | - | - | - | - | - | - | - |
| KAZA LIVE Radar Warning | - | - | - | Visual | - | X | X | X | - | - | - |
| KoDin Maps online police map, radar detector, chat | - | - | - | Both | - | X | X | - | - | X | - |
| LuxSpeed | - | X | X | Both | - | X | X | - | - | - | - |
| MapcamDroid Radar detector | - | - | - | Visual | - | - | - | - | - | - | - |
| NSW Radar Alert[b] | - | - | - | Both | - | - | X | - | - | - | - |
| PhantomALERT | - | - | - | Both | - | - | X | X | X | - | - |
| piPOIAlert - Speed Camera | - | - | - | Both | X | X | - | - | - | - | - |
| POIbase speed camera warner | X | X | X | Both | X | - | - | - | - | - | - |
| Police Camera Blitz & Detector | - | X | - | Visual | X | X | X | - | - | - | X |
| Police Detector, Radar, Blitz Camera & Alert | - | - | - | Visual | X | X | X | - | - | - | - |
| Police Speed & Traffic Camera Radar & Detector | - | - | - | Both | X | - | X | - | - | X | - |
| Radar & Police Detector: Camera, Blitz, Traffic | - | X | X | Both | X | X | X | - | - | X | - |
| Radar Beep - | - | - | X | Both | X | X | - | X | - | - | - |

**Table 3** (*continued*)

| Smartphone application | Simultaneously run with apps/vehicle[a] | | | Communication of application (audio/visual/both) | Navigation | Notify of road conditions | | | Interaction with other users | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Integrate with vehicle | Music | Other apps | | | Roadworks | Traffic | Hazards (e.g., pot holes) | Rate marked locations/hazards | Message/ ask for help | Share images/ videos/ alerts |
| Radar Detector | | | | | | | | | | | |
| Radar GO-X: HUD, Navigation | - | X | - | Both | X | - | - | - | - | - | - |
| Radar Maps, Speed Cameras, Map Navigations | - | - | - | Visual | X | X | X | X | - | - | - |
| Radar Reminder South Australia | - | - | - | Both | - | - | - | - | - | - | - |
| Radar Trap | - | X | X | Both | - | - | - | - | - | - | - |
| Radar, HUD, Map, Speed Camera | - | X | X | Both | X | - | - | - | - | - | - |
| RadarAll: Speedcam detector | - | X | X | Both | - | - | - | - | - | - | - |
| Radarbot Speed Camera Detector | X | X | X | Both | X | - | X | X | - | - | - |
| Radardroid Lite International | - | - | - | Both | - | - | - | - | - | - | - |
| Radardroid Pro | - | - | - | Both | - | - | - | - | - | - | - |
| Skip Cams: Cam detector | - | - | - | Both | - | X | X | - | - | X | - |
| South Australian Radar Alert | - | - | X | Both | - | - | - | - | - | - | - |
| Speed Adviser | - | X | X | Both | - | - | - | - | - | - | - |
| Speed Camera (Brisbane) | - | - | - | Both | - | - | - | - | - | - | - |
| Speed Camera (Melbourne) | - | - | - | Both | - | - | - | - | - | - | - |
| Speed Camera (Sydney) | - | - | - | Both | - | - | - | - | - | - | - |
| Speed Radar Detector - Police | - | - | - | Both | X | X | X | - | - | - | - |
| Speed Camera Detector: GPS Map | - | - | - | Both | X | X | X | - | - | X | - |
| Speed camera map:Radar detector & speedometer | X | X | X | Visual | X | - | X | - | - | - | - |
| Speed Camera Radar | - | X | X | Both | - | X | X | X | X | - | - |
| Speed Camera Radar (Light) | - | X | X | Both | - | X | X | X | X | - | - |
| Speed Camera Radar (PRO) | - | X | X | Both | - | X | X | X | - | - | - |
| Speed Camera Radar Detector | - | - | - | Both | - | X | - | X | X | - | - |
| Speed Camera: Radar detector | - | - | - | Visual | X | X | X | X | - | - | - |
| Speed camera: radar, alerts | - | - | - | Visual | X | X | X | X | - | - | - |
| Speed Camera: Radarbot & Radar | - | - | - | Visual | X | X | X | - | - | X | - |
| Speed cameras and red lights | - | X | X | Visual | X | X | X | - | X | - | - |
| Speed cameras in Ukraine | - | - | - | Visual | - | - | - | - | - | - | - |
| Speed Cameras Radar | - | X | X | Both | X | X | X | - | X | - | - |
| Speed Cameras Radar NAVIGATOR | - | X | X | Visual | X | X | X | - | X | - | - |

(*continued on next page*)

**Table 3** (*continued*)

| Smartphone application | Simultaneously run with apps/vehicle[a] | | | Communication of application (audio/visual/ both) | Navigation | Notify of road conditions | | | Interaction with other users | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Integrate with vehicle | Music | Other apps | | | Roadworks | Traffic | Hazards (e.g., pot holes) | Rate marked locations/hazards | Message/ ask for help | Share images/ videos/ alerts |
| Speed Detector & Camera Birtz Radar, Traffic 2k21 | - | - | - | Both | X | X | X | - | - | - | X |
| Speed Trap Plus | - | - | - | Both | X | - | X | - | - | - | - |
| Speeding Alert - Calgary | - | - | - | Both | - | - | - | - | - | - | - |
| Sygic GPS Navigation & Maps[b] | X | - | - | Both | X | - | X | - | - | - | - |
| TomTom AmiGO - GPS Navigation[c] | X | X | X | Both | X | X | X | X | - | - | - |
| TomTom GO navigation & traffic | X | X | X | Both | X | X | X | - | - | X | - |
| UAE Cam Radar | - | - | - | Both | - | - | - | - | - | - | - |
| VIC Radar Alert | - | X | X | Both | - | - | - | - | - | - | - |
| Victorian Speed Camera Alerts | - | - | - | Visual | - | - | - | - | - | - | - |
| WA Speed Camera Alerts | - | - | - | Visual | - | - | - | - | - | - | - |
| Watch out: Police Camera, Speed, Work | - | - | - | Visual | X | X | X | - | - | - | - |
| WatchOUT AI | - | - | - | Visual | - | X | X | - | X | - | - |
| Waze - GPS, Maps, Traffic Alerts & Live Navigation[d] | X | X | X | Both | X | X | X | X | - | - | - |

*Note.* [a] Majority of applications did not disclose this information. [b]Duplicate application. [c]Duplicate application, also known as TomTom AmiGO - GPS & Warnings on Apple iTunes. [d]Duplicate application, also known as Waze Navigation & Live Traffic on Apple iTunes.

maps, Google Maps, Waze and others (if participants marked others, they were asked to clarify further). Finally, participants were asked to indicate their willingness to: (a) use a handheld phone when driving and (b) drive 10 km faster than the speed limit in the next month. Note that this study focused on exceeding the speed limit by more than 10 km/hr, as previous research has demonstrated that drivers can perceive lower-level speeding as unintentional (Truelove et al., 2021; 2022). Responses to these questions were provided on a 7-point Likert scale from strongly disagree to strongly agree.

**Table 4**
Summary of content analysis (N = 73).

| Features | Frequency | % |
|---|---|---|
| **Direct Punishment Avoidance** | | |
| Notify of speed cameras (yes) | 73 | 100 |
| Type (both fixed & hidden) | 70[a] | 96 |
| Warning when driving over speed limit (yes) | 30 | 41 |
| Notify of speed limits (yes) | 54 | 74 |
| Speedometer (yes) | 54 | 74 |
| **Marking locations on map** | | |
| Speed cameras | 39 | 53 |
| Police | 13 | 18 |
| Red light cameras | 7 | 10 |
| **Choose route with fewer radars** | 4 | 5 |
| **Simultaneously run with apps/vehicles[b]** | | |
| Integrate with vehicle | 10 | 14 |
| Music | 25 | 34 |
| Other apps | 26 | 36 |
| **Communicate (both visual & audio)[c]** | 51 | 70 |
| **Navigation (yes)** | 37 | 51 |
| **Notify of Road conditions** | | |
| Roadworks | 37 | 51 |
| Traffic | 44 | 60 |
| Hazards | 21 | 29 |
| **Interaction with other users[b]** | | |
| Rate marked locations/hazards | 8 | 11 |
| Message/ask for help | 9 | 12 |
| Share images/videos/alerts | 5 | 7 |

*Note.* [a] Fixed only = 2 applications; Mobile only = 1 application. [b]Majority of applications did not disclose this information. [c] Visual only = 22 applications.

### 4.3. Data analysis

Descriptive statistics are provided for each item. Chi-square and independent samples *t* tests were conducted to understand differences in the use of applications that share the location of police enforcement operations (cameras and police checkpoints) by gender and age groups. Differences in (a) willingness to engage in hand-held phone use while driving and (b) speeding were analyzed between participants who have at least one of the applications and those who do not use the applications, using an independent-samples median test, given that the responses were given as ordered data. A significance level of 0.05 was selected.

## 5. Study 2 results

The responses to questions are presented in Table 5. About half of the sample reported having access to an application that showed the location of police enforcement operations (cameras and police checkpoints). No significant differences were found in terms of age and gender in terms of access to these applications. Overall, it was found that Google Maps was the most commonly used application.

There were significant differences in terms of willingness to speed among those who have an active application versus those who did not have an active application. The independent-samples median test suggested that those who have access to the applications that show enforcement locations were significantly more willing to speed than those who do not use the applications ($p < 0.001$). However, there was no significant difference in mobile phone use while driving between those who do and do not use the applications ($p < 0.223$). These results are demonstrated in Figs. 2 and 3.

## 6. Discussion

Despite the significant investment in enforcement activities against road rules, there are a wide range of phone applications that can be used to notify drivers of these enforcement locations. While this has the potential to increase general deterrence by making drivers more aware of the various enforcement practices that are in place, the use of such applications is also likely to enable drivers to evade detection for violating road rules. Overall, it was identified that the applications primarily notify drivers of speed cameras (including either fixed speed cameras or both fixed and mobile speed cameras), while some also notify drivers of the location of red-light cameras and police presence. Notably, it was identified that there were limited explicit notifications of RBTs, RDTs, and mobile phone and seatbelt detection cameras within the applications. Study 2 identified that users of these applications were more willing to speed, but not more willing to use a hand-held phone while driving compared to non-users. This suggests that drivers are using these applications specifically to avoid being caught for speeding, yet are unlikely to use their phones illegally when using these applications. Some applications had a navigation function, which allowed drivers to be notified of these locations while they were being navigated to their destination, while others simply mapped the locations of enforcement locations, but did not have the additional ability to navigate drivers. The applications were identified to be easily accessible, with the vast majority being free to download (albeit some did include the option of in-app purchases). Some applications also involved features that could help drivers comply with the speed limit and/or avoid hazards. Further, a number of applications could also be used on additional devices, such as smartwatches, in addition to a mobile phone. Despite some of the positive features of the applications and the different types of interfaces they can be used on, they remain a concern for driver distraction, considering the need for drivers to look away from the road when using them. Overall, it was identified that applications that notify drivers of traffic enforcement locations are widely prevalent, they can be used on a variety of interfaces and include numerous additional features. The findings have important implications for stakeholders, policy, and future research.

**Table 5**
Participants reported use of the applications to avoid road rule violation detection and willingness to engage in speeding and phone use while driving behavior.

| Items | % | Total |
|---|---|---|
| **Use of apps** | | |
| Do you currently have phone applications that have active functions that show the locations of police enforcement operations (cameras and police checkpoints)? | 47.90% | 468 |
| Apple Maps | 45.50% | 224 |
| Google Maps | 70.10% | 224 |
| Waze | 55.80% | 224 |
| Others (e.g., TomTom Go, Magic Maps, Radarbot) | 4.50% | 224 |
| **Willingness to engage in risky behavior** | | |
| *I am willing to use a handheld phone when driving a moving vehicle within the next month* | | |
| Disagree | 15.80% | 468 |
| Somewhat Disagree | 7.30% | 468 |
| Neither Agree nor Disagree | 7.50% | 468 |
| Somewhat Agree | 7.30% | 468 |
| Agree | 5.30% | 468 |
| Strongly Agree | 2.40% | 468 |
| *I am willing to drive 10 km faster than the speed limit when driving a moving vehicle within the next month* | | |
| Disagree | 15.00% | 468 |
| Somewhat Disagree | 10.00% | 468 |
| Neither Agree nor Disagree | 9.40% | 468 |
| Somewhat Agree | 11.30% | 468 |
| Agree | 6.40% | 468 |
| Strongly Agree | 4.70% | 468 |

Study 1 demonstrated that the applications provided numerous opportunities for drivers to avoid punishment for road rule violations. Concerningly, five of the applications advertised that they can re-route drivers away from enforcement activities. While the other applications did not have that function, the ability of the applications to notify drivers of road rule enforcement locations meant that drivers still have the ability to change the route themselves or stop engaging in the offending behavior for the duration of time in which they are driving past the enforcement locations. Meanwhile, the applications that had the ability to mark the locations of enforcement activities on a map can allow drivers to seek out these locations before they drive and potentially change their route to avoid enforcement or decide not to engage in the behavior at all during the drive. Study 2 provided further understanding of these issues, demonstrating that those who report more willingness to drive above the speed limit also report using these applications, while there was no difference in application use for willingness to use a phone while driving. This suggests that drivers are using these applications to avoid being caught and punished specifically for speeding, with Google maps and Waze being the applications used most often for this purpose. Overall, this study identifies the large prevalence of these applications that display traffic enforcement locations and the wide range of ways in which they have the potential to be used to avoid being caught and punished for committing a traffic offense. This is alarming if the applications enable more people to avoid being caught and punished for traffic violations, since punishment avoidance has consistently been demonstrated to be one of the most salient predictors of continued engagement in offending behaviors (Fleiter & Barry, 2005; Ochenasek et al., 2021; Szogi et al., 2017; Truelove et al., 2019).

While the use of these applications can be suggested to make avoiding being caught and punished for road rule violations easier, it should also be acknowledged that they are not 100% accurate. First, while the applications can notify drivers of specific enforcement operations, there are other methods of enforcement that are unlikely to be picked up by the applications. This can include general police enforcement, especially when police officers are driving unmarked vehicles. Nonetheless, it is important to recognize that police resources are limited and in a geographically large country like Australia, encounters with police can be unlikely. Further, it is unlikely that the applications are always accurate about the enforcement locations. Some applications have their own databases and do not have the ability to post short-term enforcement initiatives. Meanwhile, many applications are based on user-generated data to inform the location of the traffic enforcement initiatives, which can create delays in the information presented by the app. While this is the first study exploring the impact of these applications on punishment avoidance, recent research by Mills et al. (in press) on Facebook police location pages identified that there can be a lag between enforcement operations being set up and subsequently posted on the Facebook pages. Further, it can take some time for posts to be removed after the enforcement initiative has ceased. However, it should be acknowledged that the setup of enforcement operations can occur in similar loca-

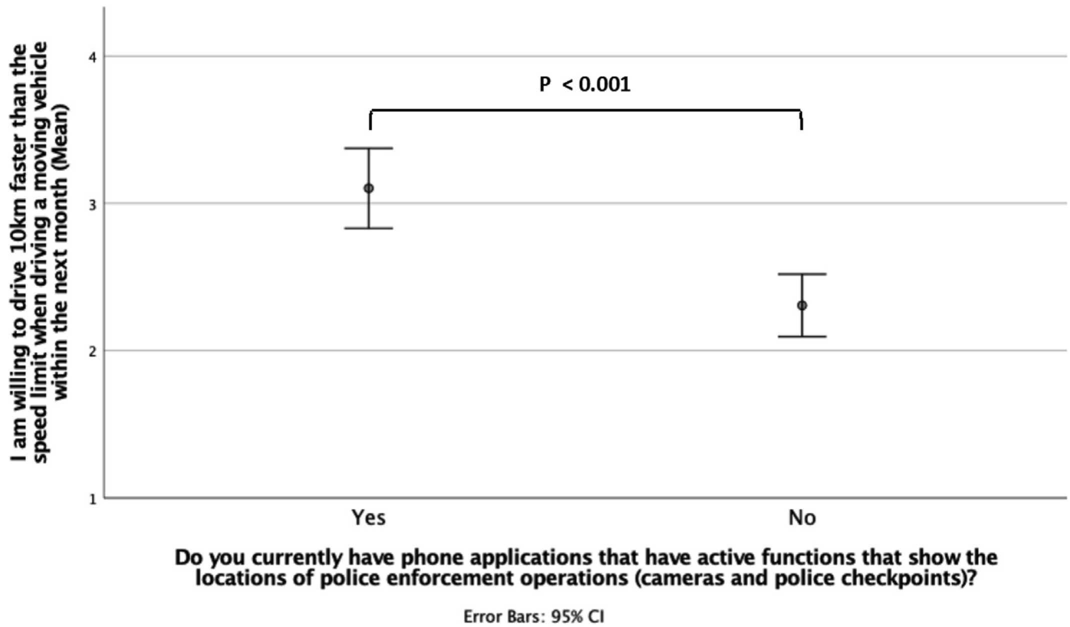


**Fig. 2.** Willingness to speed among those who do and do not use the applications that display enforcement locations.

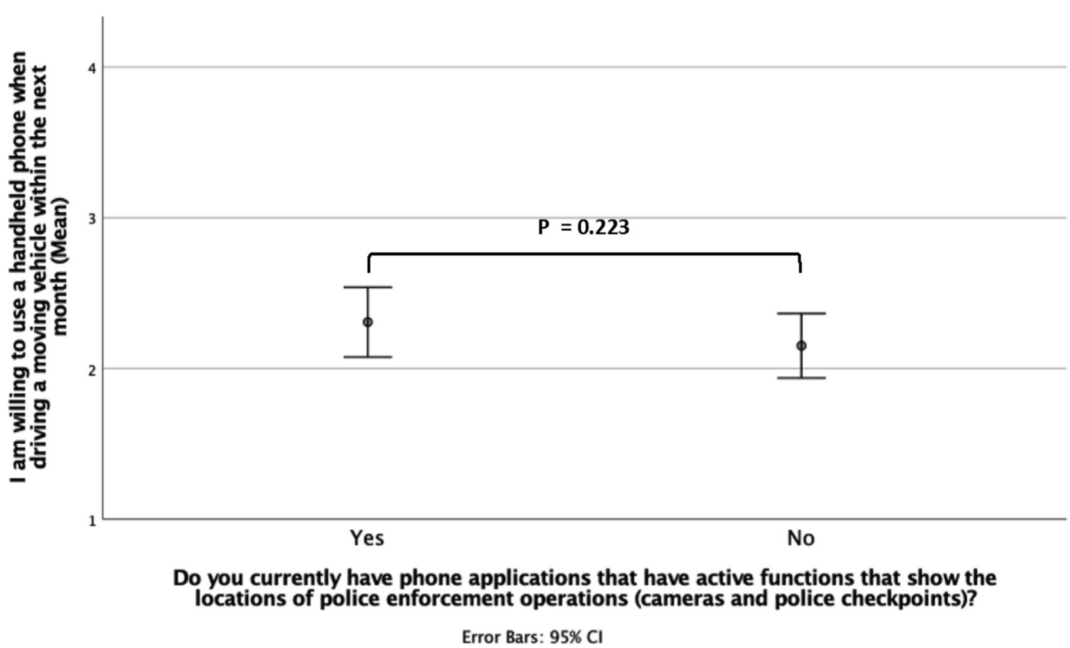


**Fig. 3.** Willingness to use a hand-held phone while driving among those who do and do not use the applications that display enforcement locations.

tions due to factors such as safety of police officers and parking convenience. As such, some drivers may be aware of locations where they believe there is a higher chance of being detected by police, regardless of their application use. Despite the possible inaccuracies, the applications appear to be widely used based on the number of downloads from some of them. This may, at least partly, be due to the fact that most of the applications were free to download, making them easily accessible.

It should also be acknowledged that some applications also included features that can help drivers comply with the road rules and avoid hazards. For example, there were some applications that notified drivers of the speed limit in the area, the speed they were currently travelling at and/or notified the driver when they were travelling over the posted speed limit. Research that has analyzed the impact of this technology including such features has found that they result in drivers reducing their engagement in speeding (Starkey et al., 2020). In addition, some applications identified in this study also notified drivers of road conditions such as road works and hazards on the road. It has been suggested that applications that notify drivers of hazards can be beneficial for road safety (Trager et al., 2021). In addition, previous studies have indicated that applications that provide feedback for road behaviors have improved fuel consumption, decreased the probability of future phone use while driving, and can alert drivers of fatigue (Bergasa et al., 2014; Dahlinger et al., 2018; Ziakopoulos et al., 2023). However, it should be noted that the research that has found these features to be a road safety benefit were analyzing applications where these features were the primary function. In contrast, the applications that were identified in this study had various additional functions, including the notification of enforcement locations, which may increase driving distraction. Notably, it has been suggested that features such as hazard identification and speed monitoring would be more appropriate if used on a windscreen head-up display, as it could reduce the need for a driver to glance away from the road and be distracted by other functions (Kim et al,.(013)). Based on the previous literature and current findings, future research could examine the use of combining feedback with these other features to enhance the positive use of these applications.

Nonetheless, in examining the nature and extent of these applications, it is also important to consider their potential impacts on driving capacity and safety. Certainly, it is well-established that mobile phone use while driving adversely affects driver performance, with studies indicating that performance deficits occur irrespective of whether hand-held or hands-free operations are utilized (Caird et al., 2008; Caird et al., 2018; Ishigami & Klein, 2009).

Thus, while research is yet to examine this directly, it could be assumed that the use of such applications when driving would ultimately reduce driver performance. Further, the fact that some applications contain multiple features (e.g., communication tools or enable simultaneous use of applications), is of particular concern given that driver performance has been shown to decrease with increasing task complexity (Li et al., 2021). Similarly, it is also concerning that such applications can be used on various devices, including in-vehicle display systems and smartwatches. Thus, given that (a) research has demonstrated that hands-free functions similarly reduce performance and (b) such features may distract the driver in some way (and to varying extents), it could be argued that the benefits of using these applications may be outweighed by the potential safety hazards they pose. Nonetheless, research is needed to examine this directly.

### 6.1. Implications

There are several implications that need to be considered from the findings of this study. First, it can be considered that relevant stakeholders and governments should actively seek to regulate the applications showing the locations of police enforcement to prevent the additional driver distraction and reduce experiences with avoiding being caught for road rule violations. Further, it was identified in Study 1 that an application that can be used to inform drivers of mobile speed camera locations was developed by a government department. Therefore, governments should also consider how the use of such applications may be undermining enforcement efforts to prevent dangerous driving, especially considering Study 2 found drivers who are using these types of applications are significantly more willing to speed.

While some applications do offer some benefits, such as notifying drivers when they are over the posted speed limit, as well informing drivers of the locations of hazards, traffic conditions and roadworks, the safety benefits of these features need to be considered in the context of the other functions on the application that can be a dangerous distraction when driving, and aid in drivers avoiding being caught for their offending behavior. It has been suggested that these features would be beneficial for higher levels of automations, such as window displays (Kim et al., 2013), which would involve less eye glances away from the road, as well as less additional distractions associated with a phone. As technology is continuing to evolve, it is timely to consider regulating functions that can promote punishment avoidance and cause a distraction. This is especially pertinent considering such technology appears to be currently primarily influencing speeding behavior, yet also has the potential to impact other road rule violations as this technology continues to evolve. Considering mobile phone detection cameras have started to be implemented in various jurisdictions worldwide, it can be considered only a matter of time before these applications are updated to include enforcement locations of these types of cameras. As the use of this technology may limit deterrence effects, more innovative ways are also needed to maximize deterrence. For example, the use of signage to suggest that drivers could be caught in areas that do not have active enforcement initiatives at that time may help contribute to higher perceptions of the certainty of being caught and ultimately less engagement in the offending behaviors.

One important lesson from this investigation is that enforcement efforts need to constantly adapt and improve to stay effective against ever-evolving technologies that may undermine them. Governments should also not rely just on one technological approach such as automated enforcement to manage risky behavior. A responsible approach to risky driving behavior is to consider potential changes of effectiveness over time and highlight the responsibility of stakeholders that are not acting on their responsibility, which is the case of mapping service providers such as Google Maps and Waze. From a policy perspective, these applications also threaten the future of automatic enforcement programs. Such programs may require rethinking the use automated enforcement as a strategy for general deterrence; instead, it may be considered a local treatment at risk points of the road network. Additionally, it is important to legally address the status of technology that might compromise the police enforcement program. In this case, we found evidence that technology-enabled behavioral adaptations could be reducing the net impact of speed cameras. Industry should proactively seek to reduce the harm that could be originated by such technology by following responsible innovation frameworks.

### 6.2. Limitations and future research

While this research presents a unique insight into the ways drivers can use technology to avoid being caught and punished for road rule violations, there are a number of limitations that need to be considered. First, Study 1 is limited to the information presented on application stores, and it could be possible that there are additional features of the applications that are not advertised (e.g., notification of false camera locations), or there are features that are advertised yet do not work sufficiently. Meanwhile, Study 2 involved self-reported data from participants in Australia. It should be acknowledged that some of these data may be subject to self-report bias and may not be representative of the entire population. Study 2 was a preliminary investigation into the types of applications that are used and how they may impact offending behavior, which opens up a number of areas that need to be explored in future research. More research is needed to understand how these types of applications are used from a driver's perspective. For example, the Technology Acceptance Model and deterrence theory may be applied in future research to further understand this type of behavior. Finally, research is needed to determine the impact of such applications on driver performance, and whether these vary depending on the interface used (e.g., in-vehicle display systems vs. smartwatches).

### 6.3. Conclusion

The present paper explores the characteristics and impact of applications that show police enforcement of traffic rules. Overall, Study 1 identified the range of existing applications that displays road rule enforcement locations and their other various features. Meanwhile, Study 2 identified that Google Maps and Waze are the most frequently used applications among the sample of Australian drivers, with those who use these types of application significantly more likely to speed than those who do not use the applications. Given that there is a wide range of applications that can notify drivers of enforcement initiatives, it is timely for stakeholders and government organizations to consider the regulation of such technology before it advances to impact road rule offending behaviors beyond speeding. Further, enforcement initiatives need to consider evolving to keep up to date with changing technology that can be used to undermine such practices and increase driver distraction.

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## Declaration of Competing Interest

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