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Overt vs. covert speed cameras in combination with delayed vs. immediate feedback to the offender

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ABSTRACT

Speeding is a major problem in road safety because it increases both the probability of accidents and the severity of injuries if an accident occurs. Speed cameras are one of the most common speed enforcement tools. Most of the speed cameras around the world are overt, but there is evidence that this can cause a "kangaroo effect" in driving patterns. One suggested alternative to prevent this kangaroo effect is the use of covert cameras. Another issue relevant to the effect of enforcement countermeasures on speeding is the timing of the fine. There is general agreement on the importance of the immediacy of the punishment, however, in the context of speed limit enforcement, implementing such immediate punishment is difficult. An immediate feedback that mediates the delay between the speed violation and getting a ticket is one possible solution. This study examines combinations of concealment and the timing of the fine in operating speed cameras in order to evaluate the most effective one in terms of enforcing speed limits. Using a driving simulator, the driving performance of the following four experimental groups was tested: (1) overt cameras with delayed feedback, (2) overt cameras with immediate feedback, (3) covert cameras with delayed feedback, and (4) covert cameras with immediate feedback. Each of the 58 participants drove in the same scenario on three different days. The results showed that both median speed and speed variance were higher with overt than with covert cameras. Moreover, implementing a covert camera system along with immediate feedback was more conducive to drivers maintaining steady speeds at the permitted levels from the very beginning. Finally, both 'overt cameras' groups exhibit a kangaroo effect throughout the entire experiment. It can be concluded that an implementation strategy consisting of covert speed cameras combined with immediate feedback to the offender is potentially an optimal way to motivate drivers to maintain speeds at the speed limit.

1. Introduction

Speeding is a major problem in road safety due to the increase it causes both in the probability of accidents and in the severity of injuries when an accident occurs (Elvik, 2009). Harsha et al. (2007) presented a general rule of thumb for the increased risk from speeding: "when travel speed increases by 1%, the injury crash rate increases by about 2%, the serious injury crash rate increases by about 3%, and the fatal crash rate increases by about 4%" (p. 3). Some researchers argue that collisions rate is more correlated with speed variance than speed level per se (e.g., Garber and Ehrhart, 2000; Lave, 1985; Quddus, 2013). However, Elvik et al., (2004) stressed that in reality there is a strong correlation between mean and variance and concluded that it might be difficult to separate the effects of mean speed and speed variance on collisions.

Police enforcement of the speed limit is one of the most effective tactics to address the dangers of speeding. Although a positive correlation between the extent of enforcement and a reduction in accident rates has not been clearly demonstrated in individual study results, this correlation has been shown when the data of those studies was aggregated in a meta-analysis (Elvik, 2011). Another enforcement tool commonly employed is to install speed cameras. Yet the evidence on the benefits of this method is still inconclusive. Some have found speed cameras to be associated with an estimated 17–25% reduction in injuries from accidents (see review in Thomas et al., 2008), or that there were resultant reductions in the number of collisions, ranging from 8% to 49% for all collisions and from 11% to 44% for fatal and serious injury collisions, in the areas where speed cameras were located (Wilson et al., 2010). Conversely, other researchers reported that they failed to find a beneficial effect on the number of collisions or injuries from speed cameras (Novoa et al., 2010; Skubic et al., 2013).

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Furthermore, Aljassar and Ali (2003) found an increase of 5% in fatal accidents after the installation of speed cameras in Kuwait. Several arguments against the use of speed cameras have been presented (Delaney et al., 2005): (1) the aim of cameras is to raise revenue for the government rather than improve road safety; (2) speed cameras are perceived as unfair because the system cannot notify the offender on the spot, which does not allow for the opportunity to explain the circumstances of the offence (as can be done with police officer); (3) the perceived reliability of speed cameras is low; and (4) speed cameras can be considered an invasion of privacy.

Speeding cameras can be either fixed cameras, which are installed in a specific location, usually a box mounted on a pillar, or they can be mobile cameras, installed in police vehicles, operated by trained policemen. These cameras can be either visible ('overt') or hidden ('covert'). Overt cameras are fixed speeding cameras, while covert cameras can be camouflaged, in their surroundings as fixed cameras or hidden mobile cameras. The added advantage of covert cameras is the increase in the uncertainty about their location. There is an ongoing debate on whether overt or covert cameras are more effective; however this effectiveness is dependent on the specific objective being targeted. Researchers have argued that overt cameras are more appropriate if the aim is to deter speeders at unsafe locations rather than to raise revenue for the government (see Delaney et al., 2005); however, other evidence has shown that covert countermeasures may reduce collision rates and average speeds more extensively than overt countermeasures (Diamantopoulou and Cameron, 2002; Keall et al., 2001). One of the shortcomings of overt cameras, unlike covert cameras, is their typical effect on drivers facing the camera, i.e., the tendency to slow down near the camera's location and to speed up after passing the camera to compensate for the loss of time. The occurrence of this effect, which Elvik (1997) named the "kangaroo effect", was shown in two different studies. Both studies found that the mean speed measured at 500 m after the location of the speed camera had increased back to match the speed measured 500 m before this location (Keenan, 2002; Nilsson, 1992 in Elliott and Broughton, 2005). Moreover, Keenan (2002) reported that 500 m after the camera's location, about 80% of the drivers were exceeding the speed limit. Consequences of such a kangaroo effect may include increased chances of a rear-end collisions if the camera is noticed by the driver at the last moment, and he or she decelerates abruptly. The trade-offs in risks and benefits of overt speed cameras are not necessarily clearly defined. In fact, Shin et al. (2009) reported an increase of rear-end collisions after the implementation of a speed camera program. A similar pattern was observed for red light cameras which were found to increase low-severity rear-end crashes (e.g., Erke, 2009; Goodwin et al., 2013; Høye, 2013). Assuming that red light cameras actually prevent many fatal injuries, this increase in the rear-end collisions is the lesser of two evils. However, this same tradeoff may not be applicable in the case speed cameras are not located at major intersections, because the probability of a fatal collision occurring exactly at the camera's location is not as high as in an intersection. Additionally, in a critical review Thomas et al. (2008) argued that although speed camera-related collisions decrement estimated to range between 20% and 25%, there may be some shifting of collisions to other places along the road; thus, the evaluation of camera programs should take this "negative spill over" into consideration. Other researchers have made similar claims concerning the localized deterrent effect of overt speed cameras, compared to a more general deterrent effect associated with covert speed cameras (e.g., Cameron and Delaney, 2010; Keall et al., 2001, 2002).

Another issue relevant to the effectiveness of enforcement countermeasures is the timing of the penalty. In most cases, the penalty for speeding is a fine, whose amount depends on the severity of the violation in some countries (e.g., in Norway, see Elvik, 1997). When the speeding violation is very severe, however, the penalty can be the suspension of the driver's license or even a jail sentence. These penalties are usually imposed a long time after the speeding violation has occurred. When considering punishment in a broader context, most studies that have examined punishment timing agree that the effectiveness of delayed punishment is reduced compared to immediate punishment (Abramowitz and O'Leary, 1990; Banks and Vogel-Sprott, 1965; Cheyne and Walters, 1969; Penney and Lupton, 1961). Kamin (1959) proposed the concept of 'delayed punishment gradient', which was confirmed with human participants by Banks and Vogel-Sprott (1965). According to this concept, the longer the punishment is delayed, the less effective it is.

In the context of traffic laws and speed limit enforcement, the implementation of these insights is not a simple task. Speeding tickets are almost always issued a long time after the actual traffic violation happened; therefore, the driver may not even remember the incident itself. One solution which might improve the effectiveness of the delayed punishment is to develop technologies that mediate the delay between the law violation, in this case exceeding the speed limit, and the punishment, i.e., getting a speeding ticket (Meindl and Casey, 2012). This solution could be efficient since in some cases it was shown that an immediate signal of the law violation followed by a delayed and probable penalty was an effective substitute to immediate punishment (e.g., Altman and Krupsaw, 1983; Perry et al., 2002). This claim is relevant to the enforcement of the speed limit, since it is conceivable to create an immediate cue (e.g., an SMS message sent to the owner of the vehicle violating the speed limit) signaling to the driver that he was caught speeding by a camera.

The aim of this study was to examine which combination of concealment and fine timing in operating speed cameras is optimal and effective in enforcing speed limits. To do so, we used a driving simulator to test the effect of four orthogonal combinations of the two variables, 'speed camera concealment' and 'feedback type': (1) overt cameras with delayed feedback (similar to the most commonly implemented scenario), (2) overt cameras with immediate feedback, (3) covert cameras with delayed feedback, and (4) covert cameras with immediate feedback. In addition, to explore the effect of time and experience on the drivers' behavior each participant drove in the same scenario three times on three different days.

2. Material and methods

2.1. Participants

Fifty-eight students of the University of Haifa participated in the experiment for monetary reward (29 women and 29 men, average age 26 years old, range 23–38). A prerequisite for participation was holding at least a 5 year driver's license. The participants were randomly divided into four experimental groups, each consisted of half men and half women: 15 participated in the condition of the overt cameras with delayed feedback; 15 participated in the condition of covert cameras with delayed feedback; 14 participated in the condition of overt cameras with immediate feedback; and 14 participated in the condition of covert cameras with immediate feedback.

2.2. Tools

The experiment took place in a partial driving simulator using STISIM Drive® software which was set to run with an automatic transmission (Fig. 1). A Logitech steering system was used, which