Accident Analysis and Prevention 106 (2017) 76–81

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Self-monitoring of driving speed

Shelly Etzioni[a,*], Ido Erev[b], Robert Ishaq[a], Wafa Elias[a,1], Yoram Shiftan[a]

[a] Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa 3200, Israel
[b] Industrial Engineering and Management, Technion – Israel Institute of Technology, Haifa 3200, Israel

ARTICLE INFO

Keywords:
Self-monitoring
Speeding
Speed variability
In vehicle data recorder
Fine size
Road safety

ABSTRACT

In-vehicle data recorders (IVDR) have been found to facilitate safe driving and are highly valuable in accident analysis. Nevertheless, it is not easy to convince drivers to use them. Part of the difficulty is related to the "Big Brother" concern: installing IVDR impairs the drivers' privacy. The "Big Brother" concern can be mitigated by adding a turn-off switch to the IVDR. However, this addition comes at the expense of increasing speed variability between drivers, which is known to impair safety. The current experimental study examines the significance of this negative effect of a turn-off switch under two experimental settings representing different incentive structures: small and large fines for speeding. 199 students were asked to participate in a computerized speeding dilemma task, where they could control the speed of their "car" using "brake" and "speed" buttons, corresponding to automatic car foot pedals. The participants in two experimental conditions had IVDR installed in their "cars", and were told that they could turn it off at any time. Driving with active IVDR implied some probability of "fines" for speeding, and the two experimental groups differed with respect to the fine's magnitude, small or large. The results indicate that the option to use IVDR reduced speeding and speed variance. In addition, the results indicate that the reduction of speed variability was maximal in the small fine group. These results suggest that using IVDR with gentle fines and with a turn-off option maintains the positive effect of IVDR, addresses the "Big Brother" concern, and does not increase speed variance.

1. Introduction

Car crashes are an acute problem world-wide, with enormous economic and social impacts. Throughout the world, over a million people are killed in car crashes, and over 50 million are severely injured, each year (Soole et al., 2009). According to some estimates, the annual cost of car crashes in the US alone is almost 300 billion dollars a year, with a staggering number of 635 casualties each week (Cambridge Systematics, 2011). Therefore, road crash prevention should be a primary goal of decision makers worldwide.

According to Leandro (2012), 10–20% of drivers exceed speed limits by over 10 km/h regularly. According to another study, one in every six drivers will receive a speeding ticket annually (Toledo et al., 2008). A large body of research points to the connection between driving speed and the probability of being involved in a car crash, as well as to the severity of possible injuries that may result (Aarts and van Schagen, 2006; Shires and De Jong, 2009). There is no doubt that focusing on speed limit enforcement can improve road safety tremendously, as it was shown that speed reduction of only 2–5 km/h may reduce the probability of crash-related injuries by 10–30% (Leandro, 2012). Furthermore, according to several estimations, around one fifth of car accident fatalities would have survived if drivers complied with speed limits (Warner and Åberg, 2008a).

Recent research suggests that in-vehicle data recorders (IVDR) can be highly effective in improving traffic safety. In fact, these devices are considered to be one of the most effective countermeasures to car crashes and conflicts (Toledo and Shiftan, 2016; Warner and Åberg, 2008b). The positive effects of IVDR may result from data recording as well as from monitoring driving behavior and providing drivers with real-time feedback. According to Warner and Åberg (2008b), installation of these devices may reduce up to 30–37% and 37–59% in injuries and casualties, correspondingly. Another study showed that the crash rate per 10,000 driving hours decreased from 6.3 to 3.91 following IVDR installation (Toledo et al., 2008). Moreover, according to a cost-benefit analysis by Carsten and Tate (2005), the benefit from routine installation of IVDR may be 15 times more than its cost. It was also shown that these devices can reduce the mean speed and the amount of time spent above speed limit (Chorlton et al., 2012; Toledo et al., 2008; Warner and Åberg, 2006, 2008b). Indeed, IVDR are believed to reduce by 40% the differences between drivers' mean speed and the advisory

* Corresponding author.
E-mail addresses: shellybz@campus.technion.ac.il, benzvishelly@gmail.com (S. Etzioni).
[1] Present address: The Sami Shamoon College of Engineering, 84 Jabotinski St. Ashdod 77245, Israel.

http://dx.doi.org/10.1016/j.aap.2017.05.024
Received 2 August 2016; Received in revised form 25 May 2017; Accepted 27 May 2017

speed limit, as provided by the IVDR (Carsten and Tate, 2005). These devices were even shown to improve driving behavior towards other road users and facilitate slightly larger headways (Adell et al., 2011).

While IVDR usage has been on the rise in recent years, many drivers still hesitate before using this technology, despite of the advantages summarized above (Assum et al., 2010; Eyssartier, 2015; Gabler et al., 2004). One of the main reasons for the non-acceptability of IVDR is the "Big Brother" concern – or the fact that people are reluctant to be monitored. A natural solution to the "Big Brother" concern is implementing a turn-off option in IVDRs, or an option to disconnect the device and eliminate data collection, in similar lines to the "Incognito" option in Google Chrome (Arazi, 2012). However, it is possible that such an option will increase speeding events and driver speed variability, as it might result in two driving patterns – with and without operating IVDR. In the same time, some studies have demonstrated that speed variability can negatively affect road safety more profoundly than high speed by itself (Navon, 2003). Thus, it is important to consider whether the benefits of improving IVDR acceptability by means of a turn-off option outweigh the associated risks.

A better understanding of optimal penalty structures can potentially decrease the negative effect of the "Incognito" or a turn-off option on speed variability. The main goal of this paper is to explore these effects, alongside IVDR with an "Incognito" option. Specifically, we examine the relation of the magnitude of speeding penalties to driving speed and speed variability. Our results suggest that the addition of an "Incognito" option is likely to have a positive effect. Implementation of IVDR with an "Incognito" option was shown to reduce over-speeding and speed variability, relative to a control condition (no IVDR, no fines). In addition, IVDR with small fines was found to be more effective than the control no-fines condition, and also more effective than IVDR with high penalties. Thus, our results reveal that the effect of the magnitude of the fines is not monotonic.

2. The difference between planning and ongoing decisions

The starting point of the current investigation is a large body of research in psychology and behavioral economics demonstrating the large gap between planning and ongoing decisions: people exhibit high sensitivity to rare events when they plan their actions (as predicted by cumulative prospect theory, Tversky and Kahneman, 1991), but tend to underweight these events in real time (Camilleri and Newell, 2011; Schurr et al., 2014; Yechiam et al., 2005). For example, Yechiam et al. (2005) found that, when asked to plan the next 100 choices in advance, most subjects prefer the safer prospect "Loss of 8 with probability of 1/200; Loss of 2 otherwise" over "Loss of 200 with probability of 1/200; Loss of 1 otherwise". However, if allowed to change their choices after gaining experience, the majority of subjects prefer the risky prospect. The planning-ongoing gap is closely related to the description-experience gap: the observation that people overweight rare events when they rely on a description of the incentive structure (Kahneman and Tversky, 1979), but exhibit the opposite pattern when they rely on experience (Barron and Erev, 2003; Hertwig et al., 2004). The planning-ongoing gap has three related implications in the current context. First, the tendency to underweight rare events in ongoing decisions sheds light on the effectiveness of IVDR systems that allow high probability reinforcement of safe driving. Specifically, the underweighting of rare events implies that a gentle fine for each reckless action (e.g., a small increase in insurance cost from each turn taken with speed over 100 km/h, indicated by a red light) is expected to be more effective than a large fine that is being imposed with a low-probability. Gentle high probability fines are expected to be more effective even when the expected returns are kept constant (Barron and Erev, 2003; Hertwig et al., 2004).

Second, the tendency to exhibit high sensitivity to rare events in planning decisions suggests that the option to disconnect IVDR does not necessarily imply high disconnecting rates. When planning future rides, people are expected to see the benefits of IVDR which is aimed at helping them avoid rare risks. High sensitivity to rare events at the planning stage can promote the use of IVDRs even if these devices incorporate fines and do not promise any monetary benefits. Indeed, it has been shown that people are expected to use IVDR even if this behavior decreases their expected monetary return (Erev and Roth, 2014).

Notwithstanding the importance of the planning-ongoing gap, research shows that this gap does not lead to large deviations from the optimal choice. When the difference in expected return between alternative is sufficiently large, most people would maximize the expected return (Erev and Haruvy, 2016). Specifically, when the use of IVDR leads to large fines, drivers will revert to disconnecting the device.

These three properties of the planning-ongoing gap suggest that "gentle" IVDR systems with an "Incognito" option can be highly effective. Using gentle fines for reckless behavior can be sufficient to eliminate this behavior, and yet it is unlikely to lead to high disconnecting rate. That is, these devices can increase safety, while minimizing the "Big Brother" concern, and without increasing speed variability. The experiment described below was designed to evaluate these optimistic predictions.

3. Methodology

A computerized speeding dilemma task was designed in order to test the impact of fine size on IVDR acceptance rate and self-monitoring, mean speed, and speed variability. While lab experiments cannot fully mimic real life, field experiments are very complex in terms of operational procedures, controlling for external factors, and being time and budget intensive. Due to our interest in the decision making process, we mimic an IVDR using a simplified car in a lab setting, while focusing on speeding information and decision making. Decision making schemes are often studied through lab experiments and are considered to have adequate external validity (Benz and Meier, 2008; Camerer, 2011; Dipboye and Flanagan, 1980).

3.1. The sample

Subjects consisted of 199 Technion students, recruited through e-mail and advertisement in the Faculty of Civil Engineering. While this group could not be considered as a representative sample of the population at large, it suffices for preliminary testing of our hypothesis. The sample consisted of 80.4% men and 19.6% women – reflecting the gender distribution in the Faculty of Civil Engineering of the Technion (80% men and 20% women). The majority of the participants had a driving license (91.5%), and out of those who had a driving license 53.3% also had an available car that they could use. Out of those with an available car, 6.2% admitted to have received a speeding ticket in the year preceding the experiment. All participants were rewarded with monetary compensation of 15 or 25 New Shekels (approximately 4–6.5 USD), according to their performance, and informed that the experiment would last about 20 min.

3.2. Procedure

In order to test the research hypotheses, we used a speeding dilemma task that was programmed in Matlab for this experiment. The participants' main task was to control the speed of a simplified "car" in a laboratory setting. The simplified "car" included "gas" and "brake" buttons, simulating automatic car foot pedals, and a speedometer. The initial speed was 90 km/p. Participants had to select their speed using the two buttons ("gas" and "brake"), which increased or decreased the speed by two km/h with each click correspondingly. In addition, a random number, drawn from a normal distribution with mean of zero and standard deviation of four, was added to the speed every two seconds. The random variable was added in order to better simulate real driving conditions, in which drivers' speed is not exclusively