Accident Analysis and Prevention 98 (2017) 118–122

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Lowering thresholds for speed limit enforcement impairs peripheral object detection and increases driver subjective workload

Vanessa K. Bowden*, Shayne Loft, Monica Tatasciore, Troy A.W. Visser

University of Western Australia, Australia

ARTICLE INFO

Article history:
Received 8 June 2016
Received in revised form 5 September 2016
Accepted 26 September 2016

Keywords:
Driving
Speeding
Attention
Policy making
Safety

ABSTRACT

Speed enforcement reduces incidences of speeding, thus reducing traffic accidents. Accordingly, it has been argued that stricter speed enforcement thresholds could further improve road safety. Effective speed monitoring however requires driver attention and effort, and human information-processing capacity is limited. Emphasizing speed monitoring may therefore reduce resource availability for other aspects of safe vehicle operation. We investigated whether lowering enforcement thresholds in a simulator setting would introduce further competition for limited cognitive and visual resources. Eighty-four young adult participants drove under conditions where they could be fined for travelling 1, 6, or 11 km/h over a 50 km/h speed-limit. Stricter speed enforcement led to greater subjective workload and significant decrements in peripheral object detection. These data indicate that the benefits of reduced speeding with stricter enforcement may be at least partially offset by greater mental demands on drivers, reducing their responses to safety-critical stimuli on the road. It is likely these results under-estimate the impact of stricter speed enforcement on real-world drivers who experience significantly greater pressures to drive at or above the speed limit.

1. Introduction

Approximately 1.25 million people die in road traffic accidents each year, with excessive speed identified as a major contributor (World Health Organisation, 2015). One approach taken to reduce speeding is to issue traffic fines/infringements for violations. Based on the success of speed enforcement at reducing accident rates (Pilkington and Kinra, 2005; Tay, 2009), it has been suggested that lowering enforcement thresholds could improve safety outcomes further (Delaney et al., 2005). Accordingly, several Australian states have recently lowered their enforcement threshold to as little as 1 km/h over the speed limit (Ironside, 2013; Knowles, 2015). At issue in the current paper is whether such reductions might unintentionally impair other aspects of safe driving.

Humans have a limited pool of cognitive and visual resources (Wickens, 2002) and fifty years of dual task literature show clear performance decrements when these resources must be divided between tasks (Goodhew et al., 2011; Logan and Gordon, 2001; Mack and Rock, 1998; Simons and Chabris, 1999). Similar decrements have been shown for individuals who drive while talking on a phone or operating in-vehicle entertainment systems (e.g. Horberry et al., 2006; Strayer et al., 2003). For example, competition for visual resources from a secondary task can result in poorer lane keeping by drivers (Engström, et al., 2005), and a reduction in their ability to detect safety critical traffic events (Greenberg et al., 2003). Cognitive resource competition can also lead to poorer traffic event detection (Horrey and Wickens, 2006), with one study showing that cognitive distraction reduced event detection by 30% in real traffic conditions (Recarte and Nunes, 2003).

Monitoring and maintaining vehicle speed already consumes driver resources, and rightly so, since safety is dependent on good speed maintenance. However, there is a risk that stricter enforcement thresholds might lead drivers to prioritize speed monitoring to the point where it drains resources from other safety-critical tasks, such as monitoring for potential road hazards (Liang and Lee, 2010). The literature suggests that speed maintenance might be a particularly resource intensive process, and thus pose significant risk. This is because it is difficult for drivers to maintain an exact speed for extended periods of time without the use of automated assistance, such as cruise control (Brookhuis and de Waard, 1999). As such, drivers typically travel within a dynamic range of speeds where the upper speed is often the perceived enforcement threshold (Stanojević et al., 2013) and the lower speed is based on time constraints or social pressures from other drivers

* Corresponding author at: School of Psychology, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, Australia.
E-mail address: vanessa.bowden@uwa.edu.au (V.K. Bowden).

http://dx.doi.org/10.1016/j.aap.2016.09.029
0001-4575/

on the road (Fleiter et al., 2010). Travelling successfully within this range requires both cognitive effort and regular monitoring of the speedometer, which directs visual resources away from the external traffic environment (Liang and Lee, 2010).

In light of these points, the aim of the current study was to investigate whether lowering speed enforcement thresholds in a simulated driving environment would introduce further competition for limited cognitive and visual resources. We compared enforcement thresholds of 1, 6, and 11 km/h over the speed-limit, corresponding roughly to recently introduced fine thresholds in Australia (Ironside, 2013; Knowles, 2015), commonly perceived thresholds amongst our current Australian participants in real-world driving (as indicated by a pilot study questionnaire, and confirmed by our current participants: $M = 4.6$ km/h), and thresholds in North America and Europe (CPS, 2016), respectively. To simulate enforcement, participants were told that triggering hidden speed cameras would reduce the value of a monetary bonus they would receive (although due to technical limitations of the simulator, their bonus was not actually tied to their speeding).

To determine the impact of lowering enforcement thresholds, a peripheral detection task (PDT) was used to measure participants' visual and cognitive resource availability (Miura, 1986). The PDT has been shown to be sensitive to variations in driver workload and resource demand in both real-world and simulated driving (Martens and Van Winsum, 2000; Patten et al., 2006). The PDT is a relatively unobtrusive measure, adding little demand to the driving task through its inclusion (Jahn et al., 2005). Participants also completed a questionnaire assessing their subjective workload (i.e., how difficult/demanding they found the experience) under the different enforcement threshold conditions. Previous research has shown that drivers who have been distracted from the task of driving safely report higher subjective workload (Horberry et al., 2006). By including the PDT and the workload questionnaire here we are able to capture both the objective speed and accuracy of participant responses to events, along with their subjective rating of the demands that driving under stricter enforcement thresholds created. Should stricter speed enforcement thresholds reduce resource availability, we would expect participants to show significant decrements in PDT performance and experience higher subjective workload when under stricter enforcement conditions.

2. Methods

2.1. Participants

Eighty-four undergraduate student participants (mean age = 21.5 years; 39 males) from the University of Western Australia participated in exchange for course credit. Participants were required to hold at least a probationary driver's licence. On average they had been licenced for 42.7 months with an average of 8.1 h per week spent driving. A sample of younger, more inexperienced drivers was used because they are disproportionately represented in accidents where speeding is involved (Palamara et al., 2013). The sample size was determined based on a power analysis ($\alpha = 0.05$; $1 - \beta = 0.80$) using an effect size found in a pilot study ($d_z = 0.31$).

2.2. Stimuli

2.2.1. Driving simulator

The driving simulator used SCANeR Studio software (version 1.4; OKTAL, France), housed in a cockpit rig supporting a 135° wide-field video driving display. Data was recorded at 1000 Hz and down-sampled to 100 Hz for analysis. The display comprised three parallel monitors, with the central monitor representing the front windscreen view and a digital speedometer (see Fig. 1). The displays also simulated two side mirrors and a central rear-vision mirror. Participants were seated approximately 85 cm from the central monitor and controlled their simulated automatic transmission vehicle using a modified Logitech computer steering wheel and pedal set. The simulated vehicle and environment were configured for left-hand drive conditions. All participants drove on a continuous 15 km road and were instructed not to turn off the road. Participants kept to the far left lane of the four-lane road, and while no other vehicles appeared in the participants' lane, there was light density traffic (~5 vehicles per min) across the other three lanes.

2.2.2. Peripheral detection task

The PDT consisted of a series of red dot targets (0.34° of visual angle) presented at a random location on the central monitor display within an area 2°–4° above the horizontal midline, and 11°–23° to the left of the participants' forward viewpoint (Martens and Van Winsum, 2000). This position is equivalent to where pedestrians and street signs typically appear in a driver's field of view (Olsson and Burns, 2000). A total of 75 dot targets (25 per threshold condition) were presented randomly within an inter-target interval of 10–15 s. Targets remained on screen for a maximum of 2 s, or until a response was made. Participants were instructed to press a button on the steering wheel as quickly as possible when a dot appeared.

2.2.3. Workload questionnaire

Participants rated their subjective workload using the NASA-TLX workload questionnaire (Hart and Staveland, 1988). Participants completed three numerical rating questionnaires (20-point scale) in total, with each rating questionnaire assessing the six subscales of workload: mental demand, physical demand, temporal demand, performance, effort, and frustration. Participants then indicated the degree to which each of these six dimensions was 'the more important contributor to workload' in pairwise comparisons between the dimensions. The overall NASA-TLX workload score was calculated by multiplying the resulting weighting of each dimension with the corresponding rating, then dividing the total by the number of pairwise comparisons.

2.3. Procedure

Participants first completed a 10 min training scenario where they were instructed to drive safely at the posted speed-limit of 50 km/h, and to respond to PDT targets. They were also told that different sections of the road would have different enforcement thresholds. After training was complete, participants were informed that they would start the experiment with a $5 (AUD) bonus that would be reduced if they were caught speeding by hidden enforcement cameras along the road. Before each condition, an instruction screen was presented for 30 s to inform participants of the upcoming enforcement threshold. Each participant drove under three threshold conditions (5–6 min per condition) where they could be fined for going: 1 km/h (*conservative*), 6 km/h (*standard*), or 11 km/h (*liberal*) over the 50 km/h speed-limit. The order of conditions was counterbalanced across participants and the experiment took approximately 35 min to complete. After the experiment, participants completed a short demographics questionnaire, which included the question of how far over the limit they believed they would have to travel before being fined in the real-world when the speed limit was 50 km/h. Participants were randomly provided with between $3 and $5 (AUD) as their monetary bonus before leaving.

Fig. 1. Central monitor view of the driving environment. Digital speedometer displayed at the bottom.

3. Results

Four participants were excluded from analysis for having scores more than 3 *SDs* from the mean on one or more of the following variables: average speed travelled, PDT response time, or PDT miss rate. Responses to the first PDT target in each condition were also excluded because these targets often occurred when the participant was still accelerating following an enforcement threshold instruction screen. In the results section we present point (effect size) and interval (within-subjects, 95% confidence) estimates (Cumming, 2012, 2013). Planned orthogonal contrasts were used to compare the *conservative* to the *standard* condition, and the *conservative* to the *liberal* condition.

3.1. Speed

Consistent with past studies, lowering enforcement thresholds reduced the average speed travelled by participants (e.g. Pilkington and Kinra, 2005). There was an effect of enforcement threshold, with average speed in the conservative condition (M = 46.0 km/h, 95% CI [45.5, 46.4]) significantly slower than in the standard (M = 48.8 km/h, [48.4, 49.3]; $t(79)$ = 14.83, p < 0.001, d = 1.38) and liberal (M = 50.6 km/h, [50.0, 51.2]; $t(79)$ = 15.04, p < 0.001, d = 1.86) conditions.

Lowering enforcement thresholds also increased the proportion of time drivers spent over the threshold, presumably due to the increased difficulty of driving within a narrower speed range. The proportion of time spent over the threshold was higher in the conservative condition (M = 4.22%, 95% CI [2.64, 5.80]) than in the standard (M = 1.27%, [.65, 1.89]; $t(79)$ = 4.03, p < 0.001, d = 0.55) and the liberal (M = 0.53%, [.25, 0.81]; $t(79)$ = 4.75, p < 0.001, d = 0.72) conditions.

3.2. Peripheral detection task

PDT performance was poorer (slower with more missed targets) under the strictest enforcement threshold condition (see Fig. 2). In the conservative condition (M = 861 ms, 95% CI [833,889]), PDT response times were significantly longer than in the standard (M = 827 ms, [801,853]; $t(79)$ = 2.13, p = 0.037, d = 0.28) and the liberal (M = 831 ms, [806,856]; $t(79)$ = 2.08, p = 0.041, d = 0.25) conditions. Similarly, the PDT miss rate in the conservative condition (M = 13.75%, [12.02, 15.48]) was marginally higher than in the standard condition (M = 11.77%, [10.18, 13.36]; $t(79)$ = 1.92, p = 0.059, d = 0.27) and significantly higher than in the liberal condition (M = 10.00%, [8.57, 11.43]; $t(79)$ = 4.04, p < 0.001, d = 0.52). Participants made few false alarms on the PDT (M = 0.23, 95% CI [.15, 0.31]), with no differences between the conservative condition and the standard ($t(79)$ = 1.03, p > 0.250) or the liberal (t < 1, p > 0.250) conditions.

Table 1
Means and within-subjects 95% confidence intervals for the weighted NASA-TLX workload subscales. Bonferroni-corrected *t*-test significance results comparing *Conservative* (1 km/h) to *Standard* (6 km/h), and *Conservative* to *Liberal* (11 km/h) are indicated (* p < 0.05; ** p < 0.001).

Workload component	*Conservative*	*Standard*	*Liberal*
Mental Demand	14.9 [13.1, 16.8]	12.7 [11.0, 14.4]**	10.7 [8.8, 12.6]**
Physical Demand	2.5 [1.5, 3.4]	2.2 [1.2, 3.2]$^{n.s}$	1.9 [1.0, 2.8]*
Temporal Demand	5.0 [3.9, 6.1]	4.3 [3.3, 5.2]*	4.1 [3.1, 5.1]*
Performance	9.2 [7.6, 10.7]	7.4 [6.3, 8.5]*	6.5 [5.3, 7.6]**
Effort	13.6 [11.8, 15.3]	11.2 [9.5, 12.8]**	9.4 [7.8, 11.0]**
Frustration	4.8 [3.3, 6.3]	3.4 [2.3, 4.6]**	3.3 [2.1, 4.4]**

3.3. Workload questionnaire

The NASA-TLX workload ratings showed an effect of enforcement thresholds on subjective workload. Workload ratings in the conservative condition (M = 50.0, 95% CI [45.9, 54.1]) were significantly higher than in the standard (M = 41.1, [37.2, 45.0]; $t(79)$ = 6.63, p < 0.001, d = 0.50) and the liberal (M = 35.6, [31.3, 39.9]; $t(79)$ = 8.83 p < 0.001, d = 0.76) conditions. Table 1 presents the subjective workload differences between conditions on each of the weighted rating subscales.

4. General discussion

There is no doubt that speeding can be deadly. However, our results demonstrate that making the enforcement threshold for speeding stricter can reduce drivers' available cognitive and visual resources, and increase their subjective workload. PDT performance under the conservative speed threshold was poorer (slower with more missed targets) than when the threshold was less strict. The implication is that lowering thresholds may reduce attention

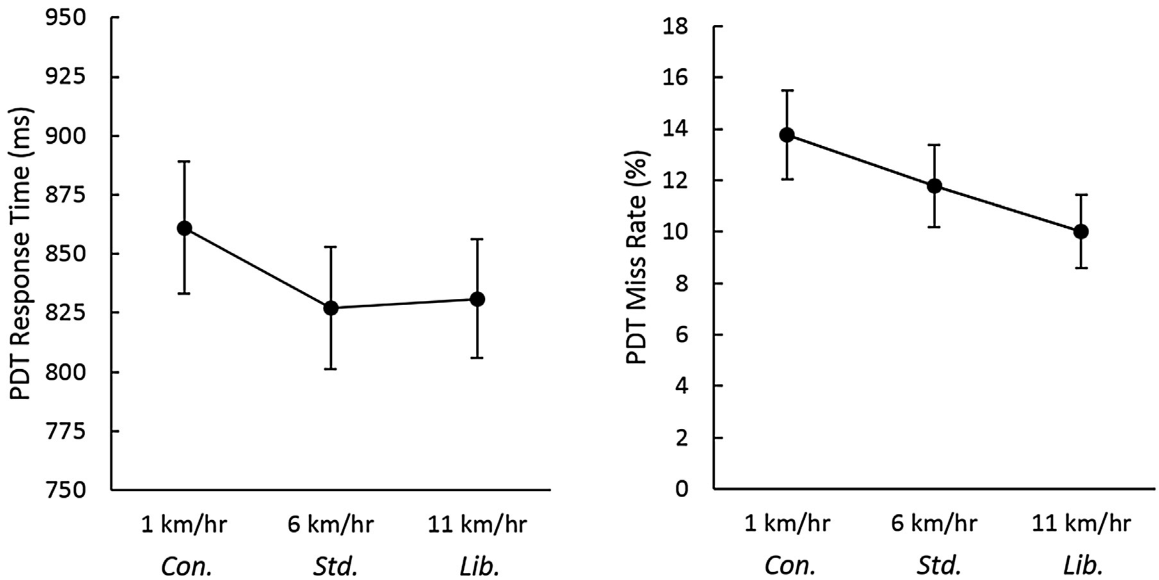

Fig. 2. Peripheral detection task (PDT) response time and accuracy data for *Conservative*, *Standard*, and *Liberal* enforcement thresholds with 95% within-subjects confidence intervals (Cumming, 2012, 2013).

to the driving environment and impair hazard detection. In addition, subjective workload ratings indicated that participants had to invest more effort in driving when under conservative conditions. This is of particular concern because increasing driver workload has been shown to degrade driving performance (e.g. reduced steering activity, poor distance estimation; Engström et al., 2005) and increase driver fatigue (Liu and Wu, 2009; Matthews and Desmond, 2002).

While the PDT is sensitive to both cognitive and visual distractions (Martens and Van Winsum, 2000; Olsson and Burns, 2000), it is possible that our PDT results reflect only visual distraction. It may be that participants spent more time looking at the speedometer during the conservative condition, and that this led to the impaired PDT performance observed. While this in itself would be a significant outcome of the current research, it nevertheless seems unlikely that visual competition alone would also lead to the observed increases in subjective workload, particularly since the mental demand component of the NASA-TLX increased significantly. We therefore suggest that stricter enforcement thresholds increase demands on both visual and cognitive resources. Future studies could incorporate measures of eye-movement and pupil dilation to investigate the relative involvement of these two resource components (Liang and Lee, 2010; Tichon et al., 2014; Wierda et al., 2012).

A possible objection to our conclusions is that they are based on relatively small effect sizes. We make two points in response. First, given the large number of drivers and varying conditions on the road, even small changes in workload and cognitive and visual resource availability could potentially translate into large differences in accident frequency and severity. Second, the results from our simulated driving task almost certainly under-estimate the impact that stricter enforcement thresholds would have in the real-world (Horrey and Wickens, 2006). For example, the use of a digital speedometer likely made it quicker and easier for participants to check their current speed compared to analogue speedometers commonly used in real-world driving. Additionally, participants had very little pressure to exceed the speed-limit (aside perhaps from a desire to finish the experiment quickly) while in the real-world, slow driving is a major cause of aggressive behaviour from other drivers and time pressure is common (Björklund, 2008; Stanojević et al., 2013). We suggest that the absence of social and temporal pressures to drive faster likely explains why our participants generally remained under the speed-limit of 50 km/h, despite being able to travel faster without consequence in the standard and liberal conditions. It is likely that real-world pressures to drive faster would increase the size of the effects reported here because they provide drivers with less opportunity to moderate their workload in demanding conditions by driving more slowly (Engström et al., 2005; Horberry et al., 2006). These pressures to drive faster, combined with stricter enforcement thresholds, would reduce the available dynamic range of acceptable speeds and thereby increase the need for cognitive and visual resources to be devoted to speed monitoring and maintenance.

The implications of the current study are most relevant to situations where covert speed enforcement is involved (e.g. hidden speed cameras, unmarked police cars etc.). This is because if drivers do not know where enforcement is located, but suspect it may be present, then the period of increased speed monitoring will last longer and the detrimental effects could accumulate (e.g. driver fatigue; Liu and Wu, 2009; Matthews and Desmond, 2002). One way to avoid these detrimental effects and still gain the speed reduction benefits is to use overt speed enforcement. This overt enforcement could be located where speeding is known to be problematic, such as at busy or dangerous traffic areas. For it to be most effective, drivers would need to be made aware of the enforcement in advance through clear and specific signage.

Future research will be required to confirm whether the increased demand on resources and workload reported here corresponds to less safe driving outcomes. It may be the case that drivers are aware of the higher demands associated with stricter enforcement conditions, and are then able to optimize resource allocation in those circumstances. For example, a driver who is aware that speed enforcement is active in a particular area may choose to avoid distracting activities, such as talking with a passenger or daydreaming, for that period of time. Under these conditions, stricter speed limits might yield compensatory benefits by reducing the frequency of other distracting activities. While there are some indications that drivers can act in such a compensatory manner under some conditions (e.g. by moderating conversations with passengers – Drews et al., 2008; Rakauskas et al., 2004), it remains to be seen if drivers are able to act similarly to reduce the load caused by stricter speed enforcement thresholds.

5. Conclusions

Lowering speed enforcement thresholds is an effective way to reduce speeding (Pilkington and Kinra, 2005; Tay, 2009). However, the current study shows that the benefits of reduced speeding can be at least partially offset by increased driver mental workload and additional demands on drivers' limited cognitive and visual resources. Policy-makers will therefore need to carefully consider the potential costs and benefits that may result from changing speed enforcement thresholds. Increased and prolonged demands on the driver caused by close speed monitoring could increase driver workload and reduce driver attention to potential hazards in the road environment.

Acknowledgement

This research was supported grant GO6176 from the Australian Neurotrauma Research Program awarded to Bowden, Loft, and Visser.

References

Björklund, G.M., 2008. Driver irritation and aggressive behaviour. Accid. Anal. Prev. 40 (3), 1069–1077, http://dx.doi.org/10.1016/j.aap.2007.10.014.
Brookhuis, K., de Waard, D., 1999. Limiting speed, towards an intelligent speed adapter (ISA). Transp. Res. Part F: Traffic Psychol. Behav. 2 (2), 81–90.
CPS 2016. Road Traffic Offences: Guidance on Fixed Penalty Notices. Retrieved from http://www.cps.gov.uk/legal/p_to_r/road_traffic_offences_guidance_on_fixed_penalty_notices/#speed.
Cumming, G., 2012. Understanding the New Statistics: Effect Sizes, Confidence Intervals, and Meta-analysis. Routledge.
Cumming, G., 2013. The new statistics why and how. Psychol. Sci. 25 (1), 7–29.
Delaney, A., Ward, H., Cameron, M., Williams, A.F., 2005. Controversies and speed cameras: lessons learnt internationally. J. Public Health Policy 26 (4), 404–415.
Drews, F.A., Pasupathi, M., Strayer, D.L., 2008. Passenger and cell phone conversations in simulated driving. J. Exp. Psychol. Appl. 14 (4), 392.
Engström, J., Johansson, E., Östlund, J., 2005. Effects of visual and cognitive load in real and simulated motorway driving. Transp. Res. Part F: Traffic Psychol. Behav. 8 (2), 97–120, http://dx.doi.org/10.1016/j.trf.2005.04.012.
Fleiter, J.J., Lennon, A., Watson, B., 2010. How do other people influence your driving speed? Exploring the 'who' and the 'how' of social influences on speeding from a qualitative perspective. Transp. Res. Part F: Traffic Psychol. Behav. 13 (1), 49–62, http://dx.doi.org/10.1016/j.trf.2009.10.002.
Goodhew, S.C., Visser, T.A.W., Lipp, O.V., Dux, P.E., 2011. Competing for consciousness: prolonged mask exposure reduces object substitution masking. J. Exp. Psychol. Hum. Percept. Perform. 37 (2), 588.
Greenberg, J., Tijerina, L., Curry, R., Artz, B., Cathey, L., Kochhar, D., . . . Grant, P., 2003. Driver distraction: evaluation with event detection paradigm. Transp. Res. Rec. J. Transp. Res. Board (1843), 1–9.
Hart, S.G., Staveland, L.E., 1988. Development of NASA-TLX (Task load index): results of empirical and theoretical research. Adv. Psychol. 52, 139–183.
Horberry, T., Anderson, J., Regan, M.A., Triggs, T.J., Brown, J., 2006. Driver distraction: the effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. Accid. Anal. Prev. 38 (1), 185–191, http://dx.doi.org/10.1016/j.aap.2005.09.007.
Horrey, W.J., Wickens, C.D., 2006. Examining the impact of cell phone conversations on driving using meta-analytic techniques. Hum. Factors: J. Hum. Factors Ergon. Soc. 48 (1), 196–205.
Ironside, R., 2013. Lower tolerance for speeding drivers creates $9 m windfall for Queensland Government. Retrieved from http://www.theaustralian.com.au/news/lower-tolerance-for-speeding-drivers-creates-9m-windfall-for-queensland-government/story-e6frg6n6-1226680973096.
Jahn, G., Oehme, A., Krems, J.F., Gelau, C., 2005. Peripheral detection as a workload measure in driving: effects of traffic complexity and route guidance system use in a driving study. Transp. Res. Part F: Traffic Psychol. Behav. 8 (3), 255–275.
Knowles, G., 2015. Demerits for 1 km/h over limit. Retrieved from https://au.news.yahoo.com/thewest/motoring/a/29924248/demerits-for-1km-h-over-limit/.
Liang, Y., Lee, J., 2010. Combining cognitive and visual distraction: less than the sum of its parts. Accid. Anal. Prev. 42 (3), 881–890, http://dx.doi.org/10.1016/j.aap.2009.05.001.
Liu, Y., Wu, T., 2009. Fatigued driver's driving behavior and cognitive task performance: effects of road environments and road environment changes. Safety Sci. 47 (8), 1083–1089.
Logan, G.D., Gordon, R.D., 2001. Executive control of visual attention in dual-task situations. Psychol. Rev. 108 (2), 393–434, http://dx.doi.org/10.1037/0033-295x.108.2.393.
Mack, A., Rock, I., 1998. Inattentional Blindness, vol. 33. MIT press Cambridge, MA.
Martens, M.H., Van Winsum, W., 2000. Measuring distraction: the peripheral detection task. In: TNO Human Factors. Soesterberg, The Netherlands.
Matthews, G., Desmond, P.A., 2002. Task-induced fatigue states and simulated driving performance. Quarterly J. Exp. Psychol. Sect. A 55 (2), 659–686, http://dx.doi.org/10.1080/02724980143000505.
Miura, T., 1986. Coping with situational demands: a study of eye movements and peripheral vision performance. Vision Veh. 1, 205–216.
Olsson, S. Burns, P.C., 2000. Measuring driver visual distraction with a peripheral detection task. Retrieved from Sweden.
Palamara, P., Kaura, K., Fraser, M., 2013. An investigation of serious injury motor vehicle crashes across metropolitan, regional and remote Western Australia. Retrieved from.
Patten, C.J.D., Kircher, A., Östlund, J., Nilsson, L., Svenson, O., 2006. Driver experience and cognitive workload in different traffic environments. Accid. Anal. Prev. 38 (5), 887–894.
Pilkington, P., Kinra, S., 2005. Effectiveness of speed cameras in preventing road traffic collisions and related casualties: systematic review. BMJ 330 (7487), 331–334, http://dx.doi.org/10.1136/bmj.38324.646574.AE.
Rakauskas, M.E., Gugerty, L.J., Ward, N.J., 2004. Effects of naturalistic cell phone conversations on driving performance. J. Safety Res. 35 (4), 453–464.
Recarte, M.A., Nunes, L.M., 2003. Mental workload while driving: effects on visual search, discrimination, and decision making. J. Exp. Psychol. Appl. 9 (2), 119.
Simons, D.J., Chabris, C.F., 1999. Gorillas in our midst: sustained inattentional blindness for dynamic events. Perception 28 (9), 1059–1074.
Stanojević, P., Jovanović, D., Lajunen, T., 2013. Influence of traffic enforcement on the attitudes and behavior of drivers. Accid. Anal. Prev. 52, 29–38, http://dx.doi.org/10.1016/j.aap.2012.12.019.
Strayer, D.L., Drews, F.A., Johnston, W.A., 2003. Cell phone-induced failures of visual attention during simulated driving. J. Exp. Psychol. Appl. 9 (1), 23.
Tay, R., 2009. The effectiveness of automated and manned traffic enforcement. Int. J. Sustain. Transp. 3 (3), 178–186, http://dx.doi.org/10.1080/15568310801915559.
Tichon, J.G., Mavin, T., Wallis, G., Visser, T.A.W., Riek, S., 2014. Using pupillometry and electromyography to track positive and negative affect during flight simulation. Aviat. Psychol. Appl. Hum. Factors.
WHO, 2015. Road Traffic Injuries – Fact Sheet. WHO, pp. 358.
Wickens, C.D., 2002. Multiple resources and performance prediction. Theor. Issues Ergon. Sci. 3 (2), 159–177.
Wierda, S.M., van Rijn, H., Taatgen, N.A., Martens, S., 2012. Pupil dilation deconvolution reveals the dynamics of attention at high temporal resolution. Proc. Natl. Acad. Sci. 109 (22), 8456–8460.