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Effects of position of speed limit signs and the presence of speed camera on Malaysian drivers' speed choice: An eye-tracking study

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Abstract

Speeding is one of the most common driving violations in the world including in Malaysia. Reducing speed-related fatalities is one of Malaysia's strategies to improve road safety. The current study aimed to investigate the effect of speed limit sign positioning and the presence of speed camera on drivers' judgments about the appropriate speed to drive and their associated eye movements. Twenty participants took part in the study, and thirty two images of roads with a range of actual speed limits were presented. In each picture the displayed speed limit was edited to 30% lower than what participants think is appropriate on average. Speed limit signs were either presented on the road or on the speed limit sign boards at the road sides, and a speed camera sign was either present or not. Drivers judged a lower appropriate speed to drive when the camera sign was present than absent, while there was a wider spread of differences between judged and displayed speed when the speed limit sign was presented on the board than on the road. Drivers were quicker in fixating and looked more at the general area in which the speed limit sign appeared. Therefore drivers' visual attention across scenes may be manipulated by the sign positions. These low-cost interventions could be useful in managing speed choice in Malaysia.

Keywords: appropriate speed; credibility; judgment; speed limit signs; speed camera

1. Introduction

A review of data from thirty-two countries across the world identified speed as one of the priority challenges for global road safety (IRTAD, 2016). Speeding is one of the most common driving violations in the world (IRTAD, 2016; Roslan et al., 2011), including in Malaysia (IRTAD, 2017). A study showed that in Malaysia, the compliance rate with the 90km/h displayed speed limit on rural roads varies between 53% and 90% (Firdaus et al., 2015, as cited in IRTAD, 2016, 2017), and more than 50% of drivers ignored speed limits (Othman, 2015). Reducing speeding related fatalities is a specific target that many countries are working on to improve road safety, including Cambodia, Ireland, Serbia and Spain (IRTAD, 2016). IRTAD (2016) reported that several countries have successfully reduced the number of road fatalities by over 50% between 2000 and 2014, and one of the contributing factors to such an impressive reduction is programmes that address the main risks such as speeding.

Speed limits are considered to be part of effective speed management by providing guidance on the speed drivers should adopt. Drivers whose speed differs greatly from the speed limit set are more likely to be involved in road accidents (e.g. Soloman, 1964). Similarly, a review paper reported that drivers whose speed differs greatly from the limit are more like to crash and speed also affects the severity of collision (Aarts & van Schagen, 2006). One of the major factors which affects compliance with speed limits is whether drivers think that the limits are credible (OECD/ECMT, 2006; Van Schagen, Wegman, & Roszbach, 2004, Van Nes, Branderburg, Twisk, 2010, Gardner & Rockwell, 1983, Kanellaidis, Golias & Zarifopoulos, 1995). When asked why they violate speed limits, one of the responses often given by drivers is that they do not regard the speed limits as being credible (Kanellaidis, Golias, & Zarifopoulos, 1995).

That speed limit credibility affects drivers' judgments about the appropriate speed to drive has been demonstrated empirically in a study where speed limit information presented to drivers was manipulated in four different conditions (Lee et al., 2017). In a first experiment, drivers were asked to view photographs of roads without speed limit information and judge the appropriate speed to drive on each road. The mean speed judged for each road was then used as a baseline to create four conditions with manipulated speed limit information, which were presented to new participants in a second experiment. These conditions included signs showing speed limits of 50% higher or lower than the speed judged to be appropriate previously (which were deemed to be non-credible) or 10% higher or lower than the speed judged to be appropriate previously (which were deemed to be credible). The results showed that drivers' judgments were consistent with the displayed speed limits that were 10% lower, but not with speed limits that deviated highly (50% higher or lower) from the appropriate speed judged in the first experiment. The findings suggest that drivers are more likely to comply with speed limits that appear credible than those which deviate highly from the speeds which they would judge appropriate in the absence of speed limit information.

1.1 Interventions to increase compliance with displayed speed limits

Various kinds of intervention have been introduced with the aim of increasing compliance with displayed speed limits. One intervention that has been implemented in some parts of the world is to increase the conspicuity of the speed limit by painting it onto the road itself rather than presenting it on a sign by the road side. This intervention may be beneficial given that drivers appear to primarily focus on features of the road itself when judging the appropriate speed to drive (Goldenbeld & van Schagen, 2007; Lee et al., 2017). If drivers do not look at speed limit signs then they would not take this information into account when they choose their speed. Moreover, even if drivers always look at the speed limit signs, making the speed limit sign larger and placing it on the road itself might increase its perceived importance when making a decision about the appropriate speed to drive. However, although this intervention has been used in several countries including the UK and Australia, only limited research has tested its efficacy. A study by Radalji (2002) investigated the effects of installation of painted 40 km/hr speed limit signs on the road on drivers' speed around school zones in Australia in comparison to the previous 40 km/h speed limit signs. The study reported no speed reduction following the introduction of the painted 40 km/hr limits. However, it is worth noting that the 40 km/h limit outside the schools only applied during restricted time periods throughout the day. Therefore, it may not be possible to generalise from this about the efficacy of painted speed limits in general.

Another intervention to reduce speed which is widely used in many countries is speed cameras and these have been found to be effective in reducing road collisions in Australia and New Zealand (Keall, Povey, & Frith, 2001), seven European countries (Elvik, 1997) and the United Kingdom (Gains, Humble, Heydecker, & Robertson, 2003). Malaysia also installed Automated Enforcement System (AES) cameras as one of the strategies in the Malaysia Road Safety Plan 2006-2010. AES uses high-technology cameras to detect offenders including those who have exceeded the speed limit. A report showed its effectiveness in increasing speed limit compliance (Rahim, Marjan & Wong, 2013; MIROS, 2020) but there are no reports as yet about its impact on reducing speed-related fatalities.

1.2 Current Study

Speeding is one of the leading causes of fatalities in Malaysia (IRTAD, 2017), and there is room for improvement in speed limit compliance rate (Firdaus et al., 2015, Othman, 2015). There may be some previous studies which focused on understanding how speed credibility and interventions help improving the compliance rate (especially focusing in developed countries, e.g. Keall et al. (2001), Elvik (1997), Gains et al. (2003)), but not many studies have been done in Malaysia. Although some technologies are available such as Intelligent Speed Adaption system (ISA) (Ghadiri et al., 2013), they are not always accessible in a developing countries due to the cost of such technologies. As one of the aims of the Road Safety Plan of Malaysia 2014-2020 is to improve speed limit compliance, this current study is highly relevant in the context. There were two primary aims in this study, the first being to investigate how the position of a speed limit sign and implied presence of speed camera affects the speed at which drivers' judge it is appropriate to drive on the roads when a set of non-credible speed limit sign values were provided (non-credible values were chosen to ensure that drivers would not comply with the limits in the absence of the experimental manipulations).

The second aim was to investigate whether those same independent variables also affected drivers' eye movements while making the judgments. As driving is a highly visual task, much previous research has focused on drivers' eye movements in road environments, with some evidence suggesting that eye movement strategies may relate to driver expertise and even crash liability (e.g. Chapman & Underwood, 1998; see Robbins & Chapman, 2019, for a review). In the context of the current study, it is important therefore to determine whether the manipulations of speed limit and speed camera information influence drivers' looking strategies as these could have unintended consequences for overall safety. For instance, it could be that it is beneficial for the speed limit sign to be presented on the road rather than on a board at the side if it enables drivers to maintain their focus at the centre of the roadway rather than diverting attention towards the roadside.

Drivers were presented with photographs of road scenes and asked to judge the appropriate speed to drive. The photographs were taken from Lee et al. (2017) and hence we already know what speed drivers judged to be appropriate to drive on each road in the absence of any speed limit information. Each photograph was presented with a speed limit value that was 30% lower than the value which drivers had judged appropriate to drive in the previous study – in other words, we deliberately presented speed limits with which drivers do not tend to comply. The location of speed limit was manipulated: it was either displayed on the board at the side of the road or painted on the road itself. On half of the trials a sign board indicating that a speed camera was present was also included.

We predicted that drivers would judge speeds that were closer to the displayed speed limit as appropriate when the speed limit was presented on the road than on the boards. We also predicted that they would judge lower speeds to be appropriate when there was a speed camera sign present in the scene than when there was no speed camera sign. We predicted that drivers would comply with the speed limits when a speed camera sign was present i.e. judge it appropriate to drive at a speed that is not significantly higher than the displayed speed.

For eye movements, we analysed attention to three areas of the roadway: the left-hand side, the right-hand side, and the road itself. We focused on these broader regions rather than fixations on the speed limit signs themselves because it would inform us whether the distribution of drivers' eye movements across the whole scene would differ as a function of the sign location. We predicted that drivers would first fixate sooner and also spend longer looking at the road sides (left and right) when the speed limit signs were displayed on the sign boards, while they would spend longer looking at the road itself when the speed limit sign appeared on the road. We further predicted that drivers would spend more time looking at the area in which the speed limit sign appeared when the speed camera sign was present than not present, as drivers would be more concerned about complying with the speed limit when there is a speed camera in the environment.

2. Methods

2.1. Participants

Twenty Malaysian drivers took part in this experiment (10 females and 10 males). They had a mean age of 22.2 years old (S.D. = 3.02), ranging from 17 to 28 years old. They also reported having a mean of 3.50 years (S.D. = 2.70) of active driving experience, ranging from 0.08 to 7.25 years, since getting their provisional license in Malaysia. All reported normal or corrected-to-normal vision.

2.2. Design

A 2 x 2 within-participants design was used. There were two independent variables: position of the speed limit sign (on the board or on the road) and the presence of speed camera sign (present or absent). The dependent variable was the appropriate speed to drive judged by participants (km/h).

2.3. Stimuli

Thirty two images of Malaysian roads from Lee et al. (2017) were used in this experiment. The actual speed limits of the roads varied, including 4 images where the speed limit was 40km/h, 4 images with a limit of 50km/h, 5 images with a limit of 60km/h, 5 images with a limit of 70km/h, 5 images with a limit of 80km/h, 4 images with a limit of 90km/h and 5 images with a limit of 110km/h. In each picture, there was originally a speed limit sign but the images were edited. The mean judged appropriate speeds for each of the images from Experiment 1 in Lee et al. (2017) - where no speed limit information was provided - were used as a baseline for creating the new speed limit values for each of the stimuli in this experiment. The images were edited to display speed limits rounded to the nearest 10 which were approximately 30% lower (mean adjusted percentage: 30.19%) than the baseline. This set of values were chosen because in order to test the effects of the interventions included in the study, we needed to ensure that drivers would be unlikely to judge the appropriate speed to drive as consistent with the limits shown in the condition where no interventions had taken place (i.e. speed limit on sign board, no speed camera sign).

Four different versions of the 32 images were created using Photoshop software where the speed limit either appeared on the sign board or instead was written on the road and there was either a speed camera sign or no speed camera sign. Pictures were presented in the resolution of 800 x 450 pixels. Figure 1 shows examples of the four versions of one of the photographs.

Figure 1. Examples of the four versions of one of the images. Top left has the speed limit sign located on the road without a speed camera sign. Top right has the speed limit sign located on the road with a speed camera sign. Bottom left has a speed limit sign located on the board without a speed camera sign. Bottom right has the speed limit sign located on the board with a speed camera sign.

2.4. Procedure

Each participant was presented with a total of 32 images in a random sequence on a Tobii T60 Eye Tracker. This eye tracker has an infrared camera integrated below a 17-inch TFT monitor. The eye tracker has high accuracy (0.5°) and drift compensation (less than 0.3°) and performs binocular tracking at a data sampling rate of 60 Hz. Participants' eye gaze was calibrated before the experiment according to the calibration procedure implemented in the Tobii Studio software. On each trial, a fixation point + appeared in the middle of the screen 500ms, followed by the image. As in Lee et al. (2017), participants were required to judge the appropriate speed to drive on each road. The stimuli were presented for an unlimited time and participants could use as much time as they wanted to write down the appropriate speed for each road in the unit of km per hour. Counter balancing was used, such that each participant only saw one of the four versions of each photograph (32 photos in total). Each participant saw 8 photographs with speed limit sign on the road with camera, 8 photographs with speed limit sign on the board with camera, 8 photographs with speed limit sign on the road without camera and 8 photographs with speed limit sign on the board without camera.

3. Results

3.1.Judged Appropriate Speed

Table 1. Mean and standard deviations of judged appropriate speed for each condition

	SL sign on board with Speed Camera	SL sign on board without Speed Camera	SL sign on road with Speed Camera	SL sign on road without Speed Camera
Judged Appropriate Speed (km/h)	66.74 (13.87)	68.75 (16.35)	64.62 (14.43)	68.41 (14.00)
Difference between Judged Speed and Displayed Speed (%)	16.74 (15.67)	19.11 (15.43)	11.98 (11.01)	18.83 (9.81)
One sample t-tests	$t(31) = 6.00, p < .001$	$t(31) = 7.10, p < .001$	$t(31) = 6.04, p < .001$	$t(31) = 10.22, p < .001$

Table 1 shows the mean judged appropriate speed for each condition along with the mean difference between the judged speed and the mean speed displayed on either the board or road. A 2 x 2 repeated measures ANOVA was conducted to test the effect of speed limit sign location (on the board or on the road) and presence of the speed camera sign on drivers' judgments about the appropriate speed to drive. There was a main effect of presence of the camera sign on judged speed, whereby drivers judge a lower appropriate speed to drive when the camera sign was present (*M* = 65.68, *S.D.* = 14.15) than when it was not (*M* = 68.58, *S.D.* = 15.18), $F(1,31) = 6.37$, $p = .017$, $\eta_p^2 = .17$. There was no main effect of the speed limit sign location, $F(1,31) = .90$, $p = .35$, $\eta_p^2 = .028$ and no interaction, $F(1,31) = .41$, $p = .53$, $\eta_p^2 = .013$.

Four one-sample t-tests were conducted to compare the difference between judged speed and displayed speed with zero, to test compliance for each condition. All four t-tests revealed significant differences, showing that participants did not comply with the speed limit sign in all conditions (see Table 1).

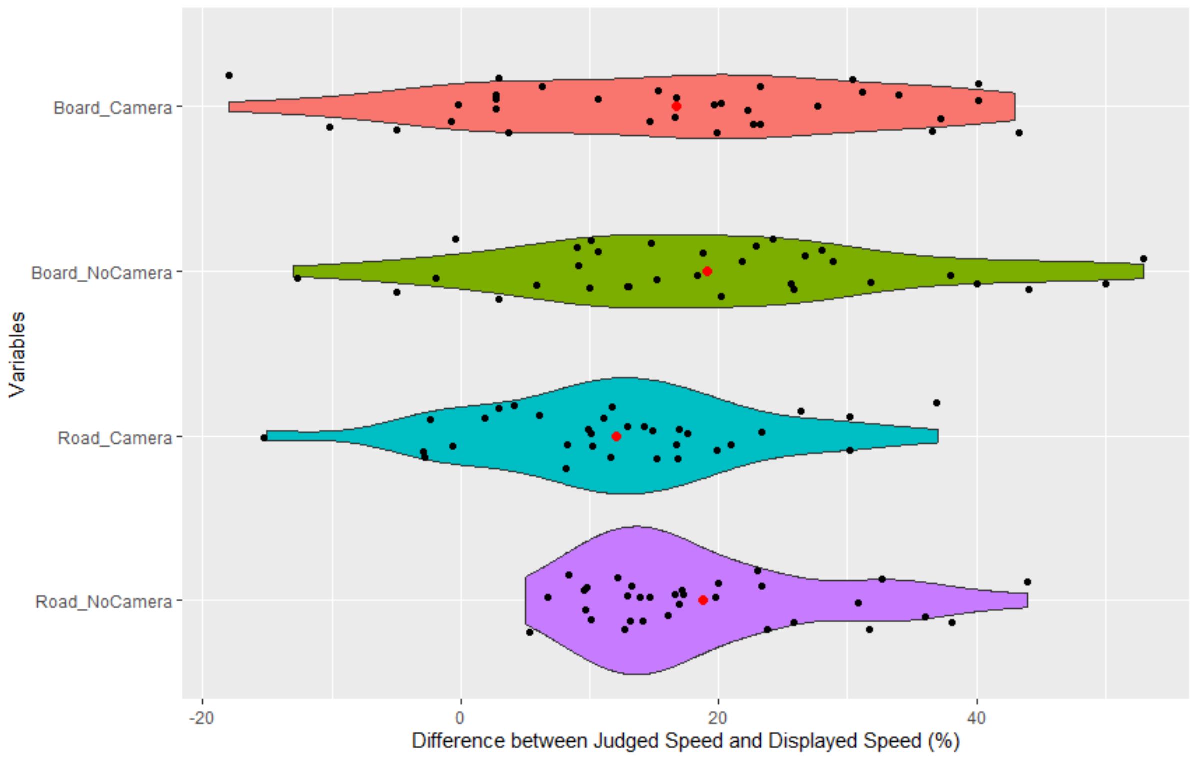

Figure 2. Boxplots of the difference between judged and displayed speed (%) for each condition (with mean percentage shown as red dots)

The spread of differences between judged and displayed speed in percentages are shown in Figure 2 for each condition. Both conditions with the speed limit signs on the board showed a wider and thinner spread as compared to both the conditions with speed limit signs on the road. It is also apparent that in the condition with the speed limit sign on the road but no speed camera sign there were no negative difference scores, indicating that for all photographs, participants consistently judged speeds higher than the displayed speed limit. In the other three conditions, there were some stimuli for which participants judged lower than the displayed speed limit. However, a Chi-square test revealed that there was no significant association between the condition and positive or negative difference scores ($\chi^2 = 4.79$, $p > .05$), indicating that although visually striking, this was not a clear difference between the conditions.

3.2.Eye Tracking Measures

The mean total fixation duration was 4210.97ms. The mean horizontal spread of fixations was 149.76 pixels and the mean vertical spread of fixations was 53.22 pixels. For each photograph, areas of interest were specified that encompassed the left side of the road, the roadway itself, and the right side (see Figure 3 for an illustration). The left side of the road occupied an average of 15.58% of the photographs, the road itself occupied 36.22% of the photographs and the right side of the road occupied 16.06% of the photographs. Two 2 x 2 x 3 repeated measures ANOVAs were conducted with speed limit location (board or road), speed camera sign (sign or no sign) and side of road (left side, road and right side) as factors. The measures included time to first fixate the region, and the percentage of total fixation duration on each side.

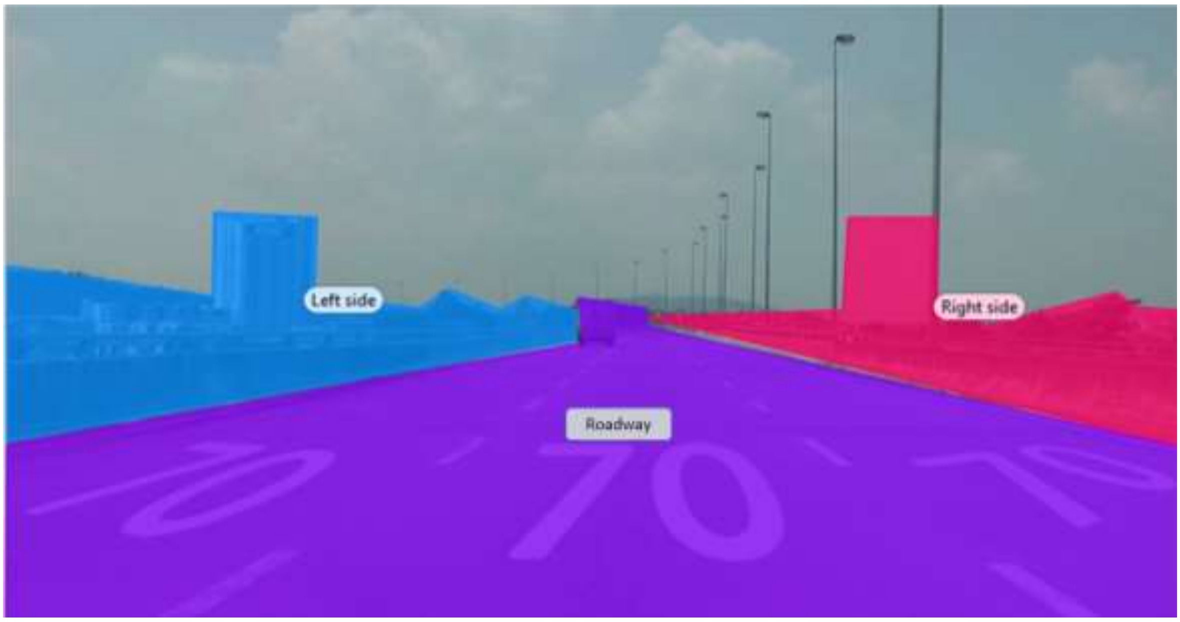

Figure 3. An example of areas of interest drawn for the left side, right side and roadway.

3.2.1 Time to first fixation

Table 2. Mean and standard deviation of time to first fixate on left side, the roadway itself, and right side of the road for each condition

	SL sign on board with Speed Camera	SL sign on board without Speed Camera	SL sign on road with Speed Camera	SL sign on road without Speed Camera
Left	0.89 (0.56)	0.90 (0.62)	1.15 (0.92)	1.41 (1.00)
Roadway	0.75 (0.41)	0.69 (0.42)	0.36 (0.20)	0.42 (0.65)
Right	1.38 (1.09)	1.19 (0.66)	1.50 (1.17)	1.61 (1.37)

For time to first fixation (Table 2), results revealed a main effect of road sections, $F(2,36) = 19.88$, $p < .001$, $\eta_p^2 = .525$. Bonferroni pairwise comparisons revealed that participants were significantly faster in fixating on the road itself (0.55s) as compared to the left hand side of the road (1.09s), $p < .001$; and the right hand side of the road (1.42s), $p < .001$. No difference was found between left and right sides of the road.

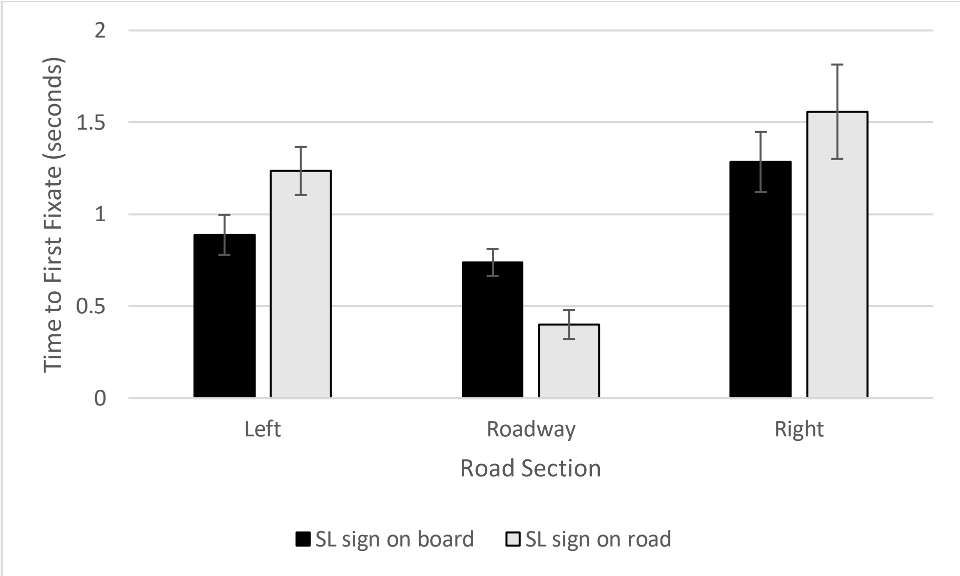

Figure 4. Time to first fixate on each road section when the speed limit sign was presented on the board and on the road (error bars depicted the SEM)

There was also an interaction between road sections and location of speed limit sign, $F(2,36) = 5.10$, $p = .20$, $\eta_p^2 = .221$, see Figure 4. Paired-samples t-tests revealed that participants were quicker to fixate on the left side when the speed limit sign was on the board (0.89s) than on the road (1.23s), $t(19) = 2.16$, $p = .044$. On the other hand, participants were quicker to fixate on the middle of the road when the speed limit sign was on the road (0.40s) than on the board (0.74s), $t(19) = 3.61$, $p = .002$. No difference was found for first fixating on the right side of the road. No other main effects or interactions were found.

3.2.2 Ratio of Total Fixation Duration

Table 3. Mean and standard deviation of total fixation duration on the left, middle, and right side of the road for each conditions

	SL sign on board with Speed Camera	SL sign on board without Speed Camera	SL sign on road with Speed Camera	SL sign on road without Speed Camera
Left	2.32 (1.17)	1.99 (0.98)	1.70 (0.71)	1.22 (0.59)
Roadway	1.18 (0.55)	1.20 (0.46)	1.81 (0.64)	1.79 (0.58)
Right	1.78 (0.61)	1.64 (0.63)	1.55 (0.64)	0.99 (0.51)

We also investigated *the total fixation duration* in proportion to the area of the area of interest (Table 3). A 2 x 2 x 3 ANOVA revealed a main effect of presence of speed camera sign, $F(1,19) = 8.19$, $p = .006$, $\eta_p^2 = .319$, whereby participants showed longer ratio of fixation duration when the speed camera sign was present (1.72) as compared to without (1.47). This was qualified by an interaction between presence of speed camera sign and road section, $F(2,38) = 4.50$, $p = .018$, $\eta_p^2 = .191$, see Figure 5. Paired-samples t-tests revealed that the ratio of the total fixation duration was significantly higher on the left when the speed camera sign was present (2.01) as compared to without (1.61), $t(19) = 3.08$, $p = .006$. Similarly on the right, the total fixation duration was significantly higher with the camera sign present (1.66) than without (1.31), $t(19) = 2.58$, $p = .018$. No difference was found for the roadway itself.

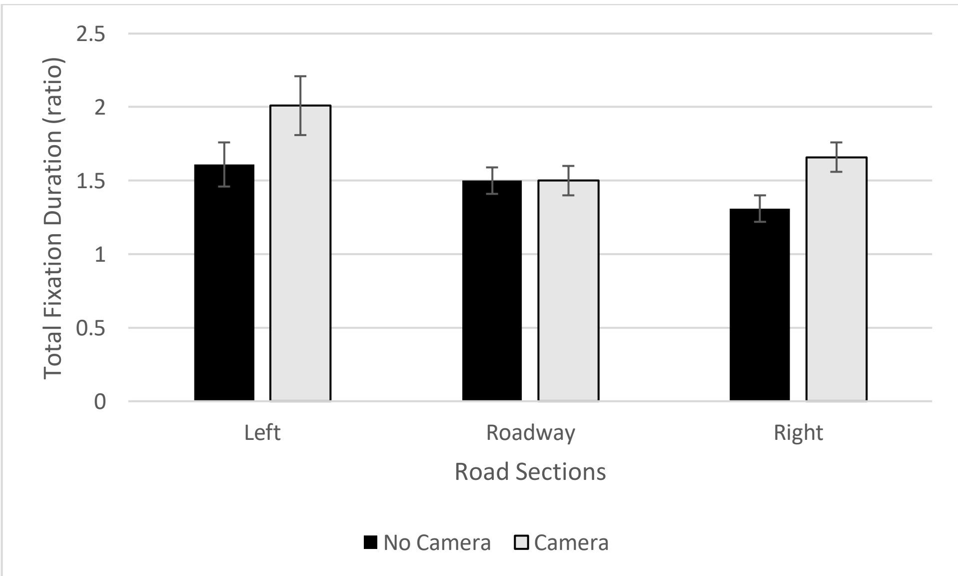

Figure 5. Ratio of total fixation duration on each road section when speed camera sign was present and absent (error bars depict the SEM)

There was also an interaction between the location of speed limit sign and road section, $F(2,38) = 29.29$, $p < .001$, $\eta_p^2 = .607$, see Figure 6. Paired-sample t-tests revealed that the ratio of total fixation duration on the left side of the road was significantly higher when the speed limit sign was located on the board (2.16) than on the road (1.46), $t(19) = 4.33$, $p < .001$. Similarly, the ratio of the total fixation duration on the right side of the road was significantly higher when the speed limit sign was located on the board (1.71) than on the road (1.27), $t(19) = 2.81$, $p = .011$. In contrast, the ratio of total fixation duration on the roadway itself was significantly higher when the speed limit sign was located on the road (1.80) as compared to on the board (1.19), $t(19) = 5.24$, $p < .001$. There were no other main effects or interactions.

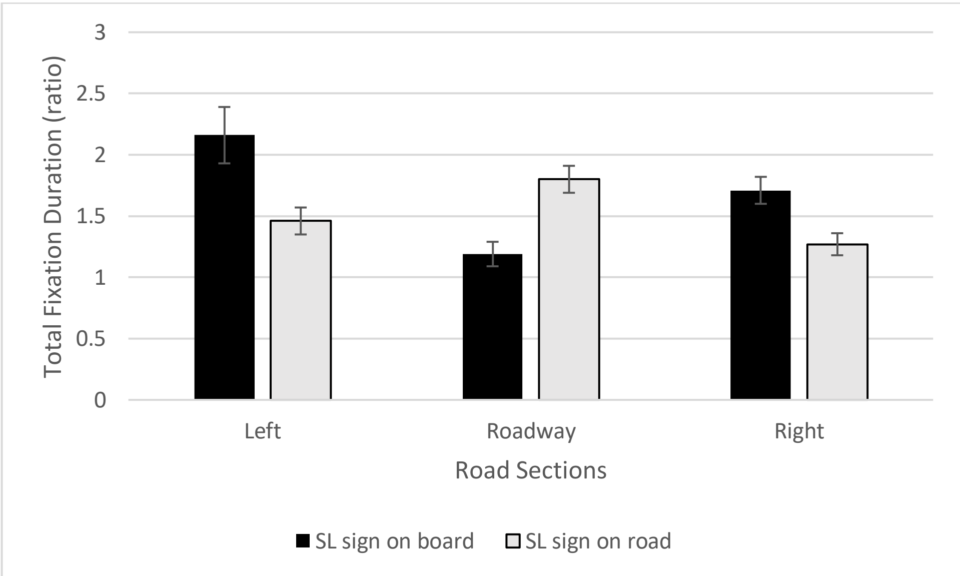

Figure 6. Ratio of total fixation duration on each road section when the speed limit sign was presented on the board and on the road (error bars depict the SEM)

4. Discussion

The first aim of this experiment was to investigate whether the position of the speed limit information and the presence of a speed camera sign affect drivers' judgments about the appropriate speed to drive. There was no difference in speed judgments made for varying locations of the speed limit sign. This suggests that the speed limit sign appearing in large print on the road did not make drivers more aware of the importance of the speed limit and adjust their judgments accordingly. However, consistent with our predictions, drivers did judge it appropriate to drive at lower speeds (and closer to the displayed speed limit) when the speed camera sign was present than when it was not. This is consistent with the speed camera being an effective intervention in many countries (Elvik, 1997; Gains et al., 2003; Keall et al., 2001) as it changes drivers' viewpoint about what is appropriate. It has previously been mentioned that one of the disadvantages of self-report surveys which ask drivers what they will do when there is a speed camera present is that drivers might not report their true driving behaviour (Blincoe et al., 2006). This study demonstrated that indicating that a speed camera might be present alters drivers' judgments in the absence of any explicit questioning.

On the other hand, although drivers judged it as appropriate to drive at a lower speed in the presence of a speed camera, they still did not comply with the displayed limit as they still selected speeds that were significantly higher in all conditions. Thus, drivers displayed a reluctance to endorse non-credible limits even in the context of speed enforcement. This adds to the body of research that suggests that credibility is critical when it comes to speed limit compliance, even with other measures in place (e.g. Goldenbeld & van Schagen, 2007; Lee et al., 2017).

It was previously suggested that risk and severity of collisions is higher when the driving speed differs greatly from the speed limit set and when there is a greater speed dispersion (e.g. Aarts & van Schagen, 2006; Soloman, 1964). When the speed limit sign was on the sign board rather than the road, the spread of responses was greater with more variable differences between the displayed speed limits and the judged speed. This seems to suggest that having the speed limit sign displayed on the road might help decrease driving speed dispersion. This could be an important safety measure as it is possible that those who behave at the extremes are at highest risk of collision.

The second aim of the study was to investigate the effect of position of speed limit sign and presence of speed camera sign on drivers' eye movements while judging the appropriate speed to drive. Overall, drivers tended to first fixate on the road itself more than the two sides of the road. This is consistent with drivers' primary visual task being to monitor the road in front, although could also be because the roadway often occupied the centre of the photographs, which is where the fixation cross appeared before each photo. Notwithstanding this general tendency to first fixate on the roadway, the position of the speed limit and the presence of speed camera signs did affect which area drivers first fixated. The time to first fixate on the left side of the road was shorter if the speed limit sign was presented on the board; on the other hand, time to first fixate on the road itself was shorter if the speed limit sign was presented on the road.

There was no significant effect of the position of the speed limit sign on the time to first fixate on the right side of the road, although there was a (non-significant) numerical trend towards the time being shorter when the sign appeared on the board. The fact that there was no significant effect for the right side of the road (even though there was for the left) could be due to the fact that the speed limit sign appeared less frequently on the right hand side of the road than the left, which reduced the experimental power for this condition. The sign appeared less frequently on the right hand side to reflect the standard arrangement in Malaysia, which is that the speed limit signs usually appear on the left hand side, although they do sometimes appear on the right. Alternatively or additionally, the lack of effect could be related to the fact that the 'view to the left' affects drivers' judged speed more than the 'view to the right' for right hand drive road systems such as in Malaysia (Lee et al., 2017; see also Goldenbeld & van Schagen, 2007). Further research is needed to clarify which of these explanations is correct. Overall, the findings are broadly consistent with the notion that drivers fixate earlier on the part of the road environment in which the speed limit sign appears.

Drivers spent more time fixating on the road when the speed limit appeared on the road itself than on a signboard, while they spent more time fixating on the left and right sides of the road when the speed limit sign appeared on the signboard than on the road. In other words, as predicted, drivers looked more at the general area in which the speed limit sign appeared. This raises the possibility that the position of the displayed speed limit could impact road safety indirectly through its effects on where drivers look within the environment. Given that monitoring the road and the surrounding traffic is the primary task of the driver, it might be beneficial for overall driving performance to present speed information in this location, rather than diverting drivers' attention to the road sides.

The speed camera sign also impacted drivers' looking patterns, whereby drivers looked more in total at the road environment when the speed camera sign was present than not. This appeared to be due to their spending more time looking at the sides of the road when the speed camera sign was present than absent, as looking time for the road itself was unaffected by the presence of a speed camera sign. One possible explanation for this might be that the presence of the sign made drivers seek to process the speed limit information more thoroughly; however, if this were the case, we might expect looking time to increase for all regions of the image when a speed camera is present. Alternatively, the increased looking time might just reflect the fact that drivers had to process the information in the speed camera sign as well as the speed limit to make their judgment, or could even suggest some degree of attentional capture by the speed limit sign. Both of these explanations are consistent with the fact that looking time only increased for the sides of the road, as the speed camera sign was never presented on the road itself.

Before concluding, some limitations of the research should be considered. In real world driving, the task is much more complex task than having to only judge the speed and it is certainly possible that these many additional demands of driving may systematically affect speed judgments. Moreover, in the current study there was no motion and drivers had ample time to locate and process the speed limit sign, if they wished to take it into account in their decisions. The location of the sign might potentially have more effect on judgments if a driver is moving quickly and carrying out multiple other tasks simultaneously, resulting in very limited time to spot and process the speed limit information. It is also important to note that the study focused on a relatively small but homogeneous group of young and inexperienced drivers. This group was considered to be of interest, because young road users are over-represented in the crash and fatality statistics, including in Malaysia (e.g. Abdelfatah, 2016) and are known to engage in risky, speeding behaviour (Smart et al., 2005) including in Malaysia (Teo & Gan, 2016). However it is possible that the findings may not be generalisable for the wider population of Malaysian drivers with greater levels of experience. Future studies should include a larger sample, more representative of the overall population of Malaysia. A further limitation is that the current study only considered one alternative location for the speed limit sign (painted on the road). There are other potential speed limit locations that are currently used in some countries - such as on overhead signs - that could be explored in future research to determine the optimal location.

We acknowledge that there are many other interventions which will also be successful in speed management. One example is the Intelligent Speed Adaption system (ISA) (Ghadiri et al., 2013) which has previously been shown to result in a significant reduction in driving speed in a study conducted in Malaysia, and has the potential to impact on speed throughout the entire drive rather than only certain road sections where speed cameras exist. Although 'installing speed monitoring gadgets in vehicles' is one of the strategies under one of five SPs

‘SP3 Safety Vehicles’ in the Road Safety Plan of Malaysia 2014-2020, the proportion of on-road cars with the ISA system installed is not known in Malaysia. Such intelligent technology might not be widely available in on-road vehicles in developing countries, with a huge portion of old vehicles still being used. According to the Road Safety Plan of Malaysia 2014-2020, one of the ultimate outcomes is ‘UO1 - Reduction in Speed’ and this has been repeated across different SPs, suggesting that it is one of the main focuses. The two midterm outcomes related to UO1 include ‘MO1 - Reduction of risk associated with road engineering’ (e.g. reviewing of speed limit for roads and vehicle types, implementation of speed control measures) and ‘MO2 - Better trained drivers’ (e.g. enhancement of current driver’s training curriculum, public education and awareness campaigns, road safety education in schools). AES will also be continued as it is one of the major strategies to improve Road Safety in Malaysia, including the joint effort with enforcement personnel and relevant authorities.

In line with the strategies in Malaysia, the current study suggests that some low-cost interventions could possibly alter Malaysian drivers’ judgments about the appropriate speed to drive as well as reduce the speed dispersion on the road, which in turn might lower speed-related crashes and fatalities. These interventions might also subtly alter drivers’ visual attentional strategies in ways that might be beneficial to overall road safety. Although the current study focused on Malaysian drivers, the findings may well apply to drivers from other countries and may be especially applicable in other developing countries where low-cost interventions are a particular priority. However, recent research has highlighted that drivers from different countries' perceptual and cognitive processes often seem to differ (e.g. Lee et al., 2015; 2020; Lim et al., 2012; 2013; Ventsislavova et al., 2019), presumably as a consequence of the unique nature of the driving environments to which they are exposed. Therefore, future research could directly compare performance of drivers from different countries on the task used in the current research. It could be the case, for instance, that drivers from "safer" driving environments, or those with higher levels of enforcement, are more likely to comply with even non-credible speed limits.

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