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Short communication

Differences in gap acceptance for approaching cars and motorcycles at junctions: What causes the size-arrival effect?

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ABSTRACT

This study investigated whether the size-arrival effect for approaching vehicles, whereby people judge that approaching motorcycles will arrive later than approaching cars, is more likely to be due to overestimating the distance available in front of motorcycles or underestimating the speed of approaching motorcycles relative to cars. Approaching vehicles at junctions (cars and motorcycles) were shown in a series of video clips (speed and distance information was provided) and photographs (only distance information was provided). Drivers' judgments about whether it was safe to pull out was investigated. The vehicle effect arose only in the video condition when vehicles were presented at a far distance. It was concluded that drivers' error in judgment is likely to be due either to the misestimation of the speed of approaching motorcycles or drivers making judgments based on the rate of optical expansion, rather than direct misperceptions of distance.

1. Introduction

Motorcycles are vulnerable road users and over-represented in road accidents and fatalities in many countries. For instance, although in the UK motorcycles constitute less than 1% of road users, in 2015 motorcyclists accounted for 8.1%% of accidents and 13.7% of deaths on the roads (DfT, 2015). In Malaysia 29.0% of accidents and 52.6% of road fatalities involved motorcycles (Sanari, Roslan, & Saniran, 2010), although Abdul Manan and Várhelyi (2012) state that only fatalities can be accurately measured in Malaysia due to underreporting and unreliable records of accidents without fatal injury. Similarly high levels of road injuries and fatalities involving motorcycles were also reported in other countries such as New Zealand (Reeder, Alsop, Langley, & Waganaar, 1999), Norway (Kopjar, 1999) and many more. Car drivers' failures to give way to approaching motorcycles at junctions (known as right-of-way violations, ROWVs) are one of the most common types of car-motorcycle collision (Abdul Manan & Várhelyi, 2012; Clarke, Ward, Bartle, & Truman, 2004). One explanation for this failure is that drivers simply do not see the approaching vehicle. The smaller frontal size of motorcycles than cars leads to conspicuity problems resulting in difficulties in motorcycle detection (Crundall, Humphrey, & Clarke, 2008; Lee, Sheppard, & Crundall, 2015; Pai, 2009). However, another factor which may contribute to the high number of ROWVs involving motorcyclists is drivers making incorrect gap acceptance judgments (Pai, 2009), whereby they decide it is safe to pull out from the junction when there is in fact insufficient room to do so safely.

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A number of previous studies have demonstrated that car drivers typically allow smaller gaps when pulling out in front of motorcycles than cars (Hancock & Caird, 1993; Hancock, Caird, & Johnson, 1991; Nagayama, Morita, Miura, Watanabe, & Murakami, 1980). In gap acceptance studies participants are typically asked to press a button at the last moment when they felt they could safely pull out from a junction while watching short videos of approaching vehicles (cars, motorcycles and trucks) travelling from a pre-specified distance from the junction at a constant speed. Previous studies using this method have revealed that drivers were more likely to accept a smaller gap size in front of motorcycles than trucks and cars, and this was true especially when the velocity of approaching motorcycle was high rather than low (Hancock et al., 1991; in line with Nagayama et al., 1980).

A widely cited explanation for this characteristic pattern in gap acceptance behaviour is the size-arrival effect, a perceptual illusion whereby people perceive smaller objects to arrive later than larger objects travelling at the same speed (DeLucia, 1991). The size-arrival effect has been demonstrated more directly in time-to-arrival studies, which present an observer with a video showing an approaching object (such as another vehicle) which is then occluded and the observer is asked to judge the time at which the approaching object would have reached them. Several such studies have found that cars were estimated as arriving earlier at junctions than motorcyclists (Caird & Hancock, 1994; Horswill, Helman, Ardiles, & Wann, 2005), consistent with the suggestion that the acceptance of smaller gaps for approaching motorcycles may be due to an error in judging the arrival time of the approaching vehicle.

While these previous studies suggest that drivers may have more difficulty judging the arrival time of approaching motorcycles than cars, resulting in gap acceptance errors (see Pai, 2011 for a review; Olson, 1989) the exact explanation remains uncertain. First, the appraisal error could be due to errors in judging the distance of the approaching vehicle. Frontal size may be used as a cue to distance (smaller objects usually are further away) and drivers might have overestimated the distance of approaching motorcycles compared with cars, resulting in drivers accepting a gap which is actually too small for them to pull out (Olson, 1989). Second, the appraisal error could be due to errors in judging the speed of the approaching vehicle (Thomson, 1980). The smaller size of the motorcycle could make drivers underestimate its speed due to the difficulties in perceiving movements of motorcycles in comparison with cars (Lee & Sheppard, 2016), resulting in their accepting a gap which is too small.

These previously mentioned gap acceptance studies were conducted using only videos, which contain both speed and distance information. Therefore, it is not possible to tell whether drivers are underestimating the speed or overestimating the distance, or both. This question can be answered by comparing gap acceptance for cars and motorcycles in videos (speed and distance information provided) and photographs (only distance information provided). The current study investigated drivers' judgment about the safety of pulling out at junctions in photos and video stimuli using the occlusion method. Drivers were presented with videos or photos depicting a vehicle approaching a T-junction viewed from the point of view of a driver who has stopped at the junction and is looking to the right in the roadway ahead. The approaching vehicle was either a car or a motorcycle and when occlusion took place the vehicle was located at one of three different distances from the junction (near – 14 m, intermediate – 30 m, far – 46 m). Drivers were required to decide whether or not they felt it was safe to pull out after each stimulus was presented.

If errors in gap acceptance judgments for motorcycles are due to drivers underestimating speed, drivers will be more likely to judge safe to pull out in front of approaching motorcycles than cars in the video stimuli but not photo stimuli. However, if the differences are due to drivers overestimating the distances of the approaching vehicles, the vehicle effect in gap acceptance should be present in both videos and photograph stimuli. Given that Crundall et al. (2008) and Lee et al. (2015) did not find any effects of vehicle type on drivers' judgments about the safety of pulling out using photograph stimuli only, we predict that the judgment errors made by drivers are more likely to be due to underestimating the speed of motorcycles in comparison to cars, and to a lesser extent in overestimating the distance/gap.

2. Methods

2.1. Participants

In total 17 drivers were recruited in the experiment (9 males and 8 females). Their average age was 22.12 years (*S.D.* = 3.16) ranging from 17 to 29 years old and they reported an average of 2.99 years (*S.D.* = 3.33 years) of active driving experience since getting their driving license in Malaysia, ranging from 0.17 to 12.42 years. All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

2.2. Design

A $2 \times 3 \times 2$ within-subjects design was used. There were three independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); type of stimuli (photographs or videos). In addition, the approaching vehicles were recorded at three different travelling speeds (30 km/h, 40 km/h, and 50 km/h). Speed was not included as an independent variable in the current study but was included to provide speed variability and make the video stimuli less predictable. The dependent variable was the participants' judgments about whether it was safe to pull out from the junction.