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Roaming the Virtual Lanes: Motorcyclists' Lane Filtering-Splitting Manoeuvres and Exposure to Road Crashes

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There is an urgent need to address motorcycle safety issues, especially in countries with high motorcycle ridership. This paper provides an overview of the research related to motorcycle movements in mixed traffic and their associated crash risk. It also highlights the factors that influence the risk of a crash from the perspective of motorcyclists and other motorists. The potential countermeasures to address the risk factors were also explored and suggestions were presented to improve the current status quo.

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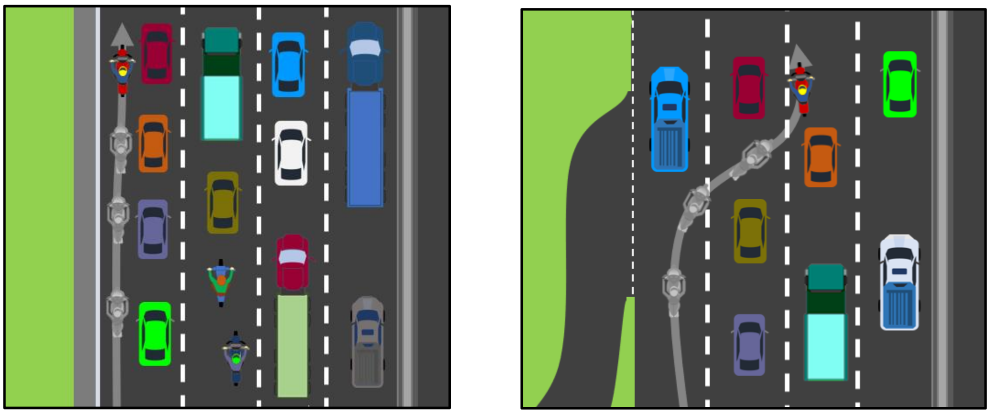
The ability to evade traffic congestion by making use of road space between other traffic that larger vehicles are unable to use is an advantage a motorcyclist may find difficult to resist. Not surprisingly, a motorcycle is a popular alternative to a four-wheeled vehicle, especially in Southeast Asia, despite the discomfort from the hot and humid weather, potentially delayed journey due to the frequent torrential downpour, and the high number of road fatalities involving motorcyclists throughout the region (Abdul Manan and Várhelyi, 2012). Due to its high power-to-weight ratio and relatively small size, a motorcycle has a high degree of manoeuvrability. This manoeuvrability advantage is frequently used by motorcyclists to pass slow-moving or stationary traffic (lane filtering) or to weave through high-speed traffic (lane splitting). Figure 1 illustrates both of these manoeuvres, which are commonly practised by motorcyclists in Malaysia (Hamzah et al., 2018; Ibrahim et al., 2018). At present, the impact of lane filtering and lane splitting manoeuvres on motorcycle crash risk is understudied, particularly through a collection of naturalistic driving data. This paper sets out to highlight the findings from previous research and a recently concluded naturalistic motorcycle riding data collection efforts involving Malaysian motorcyclists.



(B) : Lane filtering (intra-lane) (A) : Lane splitting (inter-lane)

Figure 1: Depiction of the two different types of motorcycle manoeuvres in mixed traffic

In the context of the traffic system, the crash risk surrounding motorcycle lane filtering and lane splitting manoeuvres can be explained using the Driving Task Model as the foundation (Smiley and Dewar, 2010). Driving or riding a motor vehicle can be characterized as a product of many subtasks. The three major subtasks are (i) control of a vehicle (speed and lane positioning), (ii) guidance (interaction with other vehicles through headway control) and (iii) navigation (following a path to reach a destination). In practice, the process of riding a motorcycle in mixed-traffic involves sampling a plethora of information, making numerous decisions, and performing necessary control actions (AASHTO, 2011). The amount of information and the complexity of the decision-making process influence a driver's reaction time, which in turn influences the risk of a collision. Drivers take a longer time to respond when decisions are complex or events are unexpected. In principle, the practices of lane filtering and lane splitting add to the complexity and unexpectedness of the traffic flow.

Findings from Previous Research

Lane filtering and lane splitting have been found to increase the risk of a crash. Clabaux et al. (2017) conducted an analysis of a set of motorcycle crash data collected on sections of roads in the city of Marseille, France from the year 2007 through 2009. They found that the risk of injury crashes was 3.94 times higher for motorcyclists who practised lane filtering or lane splitting compared to those who did not, regardless of motorcycle categories or the spaces used (e.g., along bus lanes, or in between traffic). Incidents related to lane changing or overtaking manoeuvres were found, in a Malaysian study, to have 7.81 times higher odds of causing a near-crash to a motorcyclist as compared to incidents related to braking or sudden stopping (Ibrahim et al., 2018).

According to the previous research, the link between lane filtering-splitting manoeuvres and the increase in motorcycle crash risk can be explained through a number of factors. One of the factors is the inability of other motorists to see the motorcycle's movements within the traffic flow. Additionally, these movements may violate the expectations of other traffic users (i.e., car, truck drivers). Highlighting these factors, lane filtering and lane splitting were found to be the cause for a motorcyclist to be less perceivable and less expected by other motorists (Beanland et al., 2015; Clabaux et al., 2017; Salmon et al., 2013). The mismatch between drivers' expectations and motorcycles' manoeuvrability was reported as the cause of collisions involving drivers turning across or making a U-turn onto the path of filtering motorcyclists (Crundall et al., 2008).

Another crash risk factor related to motorcycle lane filtering and lane splitting manoeuvres is the higher probability of errors that occur by either the motorcyclist or other motorists. In an in-depth motorcycle crash study, Clarke et al. (2004) analysed a sample of 1,790 crash cases, collected in the U.K. from 1997 to 2002, involving motorcyclists of all ages. The researchers found that the other motorists were twice as likely to be fully or partly to blame in filtering incidents, due to errors in anticipating the motorcyclists. Mulvihill et al. (2013) conducted a naturalistic riding study in Australia to investigate the influence of lane filtering on motorcycle rider situation awareness at intersections. The researchers found that motorcyclists who filtered tended to focus less of their attention on the perception of surrounding hazards and traffic behaviour than motorcyclists who did not filter. Further, lane filtering forward when approaching a junction has been linked to a tendency to run red lights among motorcyclists (Abdul Manan et al., 2019). In addition, motorcyclists were found to have a higher probability of riding with excessive speeds when they were splitting between lanes compared to when riding without other vehicles nearby (Abdul Manan et al., 2017).

Ibrahim et al. (in press) conducted a small-scale naturalistic motorcycle riding study to investigate the risk factors associated with lane filtering and lane splitting among motorcyclists in Malaysia. The experimental work provided one of the first field investigations into this safety issue. The study recruited four motorcyclists and supplied them with a Garmin VIRB XE action camera to record their riding data for a month. The helmet-mounted camera recorded the footage of the front view, motorcycle speed, distance of travel, positioning data and acceleration data. The researchers identified 258 safety-critical events (SCEs), with a staggering 96.5% of them occurred while the participants were filtering or splitting in between lanes. In a particular near-crash case, a participant was splitting in between lanes at a speed of more than 100 km/h and was nearly sideswiped by a car who was moving from the fast lane to the middle lane (Figure 2). The video analysis indicated that the driver of the car was not using the turn signal during the event. The motorcyclist was wearing a reflective jacket. This particular scenario suggests that the motorcycle was within the car's blind spots and the car driver may not have effectively checked his blind spots for other vehicles.

Figure 2: A motorcycle near-crash during a lane filtering manoeuvre

From the perspective of heavy vehicles, the safety of motorcyclists during lane filtering and lane splitting movements could be compromised further by visual limitation and blind-spot issues. The large blind spot locations around heavy trucks (Figure 3) present hazards for surrounding traffic. As reported in Schaudt et al. (2008), truck crashes involving lane changes, merges, and turns were identified in more than 26,000 crashes over a two-year period. Though these blind spots can "hide" surrounding vehicles of all sizes, smaller vehicles (like motorcycles) can be hidden from the truck driver's view with relative ease.

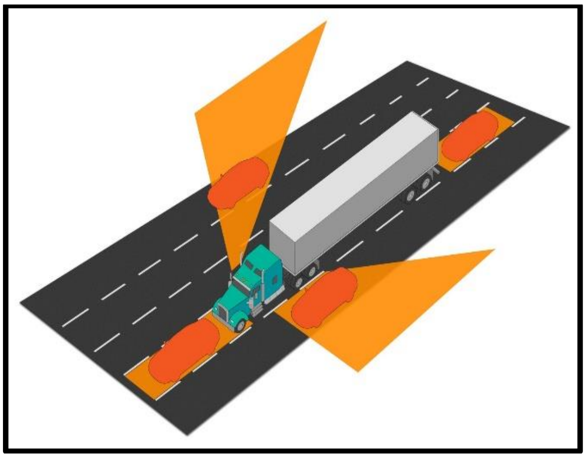


Figure 3: Depiction of the blind spots around heavy trucks (Dunn et al., 2016)

Discussion

Clabaux et al. (2017) concluded that all measures that can discourage lane filtering practices on urban roads would be beneficial to road safety. The researchers proposed a combination of lane width reduction and placement of medians, especially at conflict points (e.g., junctions and pedestrian crossing) as the main road engineering approach to reduce the likelihood of motorcycle lane filtering. Another measure suggested in their study are the provision of a reserved lane for motorcyclist within the carriageway or next to it (i.e., paved shoulder). This measure is also suggested by Abdul Manan et al. (2019).

The crash risk factors identified in the previous studies (e.g., Beanland et al., 2015; Clabaux et al., 2017; Crundall et al., 2008; Salmon et al., 2013) have pointed to the need for an excellent hazard perception and responding skills among both motorcyclists and other motorists to minimize the risk of a collision. Hazard perception skill among motorcyclists has been found to be associated with their crash involvement (Cheng et al., 2011). Thus, an approach is needed to improve this skill among motorcyclists. One of the most appropriate places to start is during the training and licensing stage. Hazard perception skill has been found to be transferrable through training in a previous study (Wallace et al., 2005). Further, situational awareness skill training and assessment should be made compulsory for licensing purposes.

The findings reported by Ibrahim et al. (in press) and Schaudt et al. (2008) have a number of practical implications for motorcycle safety. Taken together, these findings demonstrated a definite need for improvement in driver's vision around the vehicle and the detection of motorcyclists in blind spot locations. The recent advances in video processing and motion detection technologies should be leveraged for this improvement. As proven in the previous studies involving heavy vehicles, the utilization of Camera/Video Imaging Systems (C/VISs) was found to be effective in improving drivers' awareness of surrounding objects (Fitch et al., 2011; Wierwille et al., 2010). In addition, research by Fernandez et al. (2013) has demonstrated the effective use of a real-time vision-based blind-spot warning system to detect the fast-moving motorcycles in the blind spot zones during both daytime and night-time. Further, the adoption of Connected Vehicle Systems (CVS) technology and its safety applications for motorcycle could be very beneficial and fitting to solve the safety issues surrounding lane filtering and lane splitting manoeuvres. A field study conducted by Viray et al. (2016) has demonstrated the feasibility of the implementation of CVS safety applications on motorcycles.

Conclusion and Recommendations

This paper has highlighted a number of issues that should be further investigated with respect to motorcycle manoeuvres in mixed traffic. Though some research has been conducted to investigate this topic, additional studies, including naturalistic driving research, should be conducted with a sufficiently large number of motorcycles that can allow for detailed analysis. By understanding the problem, and its nuances, countermeasures can be developed to address specific crash configurations and address risk.

With the need for additional naturalistic data noted, there are a set of themes that this paper has identified that can be acted upon in the near-term to address the risk factors associated with motorcycle lane filtering and lane splitting, namely: (i) roadway structural changes, (ii) training and education for motorcycle riders, (iii) training and education for those that share the road with motorcycle riders, and (iv) technology countermeasures like C/VIS, blind spot detection system and CVS.

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