Lane Splitting on California Freeways

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4,624 Words

2 Tables

7 Figures

Submitted:

ABSTRACT

Lane splitting is the practice of passing slower moving traffic by riding a motorcycle in the gap between two parallel lanes of traffic heading in the same direction. California is the only state in the U.S. that does not ban it. In order to address the lack of empirical data about lane splitting, this study examines contemporary data collected by monitoring freeway video cameras and simultaneous speed data at the camera location. It also examines data from 900 on-scene, in-depth motorcycle accident investigations in Los Angeles in 1976-77 – the most complete and recent U.S. in-depth motorcycle accident data available. It compares the frequency of lane splitting motorcycles observed in moderate or heavy traffic to the frequency of motorcycles that crashed while splitting lanes. The results show 1) the frequency of lane splitting on the freeway declines as speed increases, and the decrease is particularly sharp when average traffic speeds exceed 40 mph (65 km/hr), 2) lane splitting occurred in less than 1% of all motorcycle accidents and and 7% of freeway crashes; 2) lane-splitting crashes occurred almost exclusively in heavily congested traffic, usually on freeways and 3) lane-splitting motorcycles were under-represented in the 1976-77 crashes: they were 63% of motorcycles observed in heavily congested freeway traffic lanes but only 29% of the crashes – a difference that was statistically significant. The absolute numbers of lane splitting crashes are small and therefore need confirmation. However, if this finding remains valid, then laws that ban lane-splitting may increase crash risks for motorcyclists.

INTRODUCTION

Figure 1. A gap sufficient for motor-cycle lane splitting.

Lane splitting (also called lane sharing, filtering or stripe-riding) is the practice of passing slower traffic by riding a motorcycle in the gap between two parallel lanes of traffic heading in the same direction. It is banned in every one of the United States except California. (California law neither explicitly permits nor bans lane splitting. It is tolerated by police in California as long as it is done with "reasonable safety," which usually means not going too much faster than surrounding traffic. When a bill to ban the practice was introduced in the state legislature in the mid-1980s, it was withdrawn – at the request of the California Highway Patrol.) These bans appear to have occurred despite the absence of any data to show that lane splitting is actually dangerous. Sperley and Pietz (*1*) reviewed the literature on "motorcycle lane sharing" but found no studies that address the comparative safety of lane splitting versus not-lane-splitting. The intent of this paper is to begin filling the gap in information about lane splitting compared to maintaining a normal lane position.

The alternative to splitting lanes is to maintain a "normal" lane position in the center of the lane or a few feet (~1 m) to either side of center – approximately the same position occupied by a car. As Figure 1 shows, the gap between two lanes of cars is often 4 – 6 feet wide (1.2 – 1.8 m). Since motorcycles are about 2½ feet wide (.75m), there is plenty of room for a motorcycle to pass between cars.

Of course, lane splitting is not without risk, but then neither is maintaining a normal lane position. The primary risk to a rider splitting lanes is a car suddenly changing lanes across or into the motorcycle's path. However the risk that a car might change lanes into the motorcycle's path does not disappear when the rider is maintaining a normal lane position. Most motorcycle-car crashes occur when a car driver fails to see a motorcycle and making an unsafe lane change after failing to see a motorcycle in an adjacent lane is just another variation on the common problem. In addition to the risk of a lane-change crash, motorcyclists in a normal lane position face the risk of a rear-end collision, with the motorcycle striking the rear of the vehicle ahead or being struck from behind by a vehicle following it too closely.

Current data on the frequency of lane splitting during daylight, weekday "rush hour" conditions was collected for selected locations on California freeways in May, June and July, 2011 by monitoring real-time video feeds from cameras of the California Department of Transportation that can be viewed over the internet. At some locations monitoring traffic as it moves is possible but no means was found for recording the video feed itself. At other locations, still images from the video cameras and average speed of traffic could be captured and recorded .

The 2011 data are compared to data collected in 1976-77 as part of the so-called "Hurt Study" – (*2*)the on-scene, in-depth investigation and reconstruction of 900 motorcycle accidents in the City of Los Angeles performed by a team of investigators at the University of Southern California (USC) headed by Professor Harry Hurt, Jr. Using the USC data to explore lane splitting requires an explanation if not an apology.

Certainly more recent data are urgently needed, but no similar study has been conducted anywhere in the United States in the 35 years since these data were collected.. A new motorcycle accident study began in Southern California in June, 2011 but it appears that fewer than 250 cases will be collected. Since lane splitting occurred in less than 1% of the 900 accidents in the Hurt study, it is unlikely the new study will have sufficient data on lane splitting to provide current or more definitive data. Therefore, the data collected in Los Angeles in 1976-77 may be the most extensive U.S. data available on lane splitting for the indefinite future.

METHODS

Exposure data collection, 2011

The California Department of Transportation (Caltrans) maintains a network of cameras along freeways which can be monitored in real time at numerous locations all over the state (http://video.dot.ca.gov). In addition, still images from video cameras can be captured and examined for motorcycles in traffic at www.sigalert.com. An example is shown in Figure 2. Monitoring data at the "sigalert.com" traffic cameras allows collection of data about average traffic speeds at the time of observation, because the website posts average traffic speeds, updated every few minutes. This allows comparing the frequency of lane splitting to average traffic speeds. The still images were copied to a Word document along with information on date, time and reported average traffic speed.

Figure 2. Arrows show motorcycles splitting lanes. 2011-05-25, 1716 hrs, 21 mph average.

Figure 3. Police motorcycle splitting lanes in heavily congested traffic while another motorcycle in light traffic maintains a normal lane position.

Of course, not all the cameras provide usable images. Los Angeles County video cameras proved inadequate for monitoring live-action video because it was not possible to monitor via internet a single camera for more than a few seconds. Instead, an internet link would feed video for several seconds from perhaps a dozen cameras in sequence, only a few of which provided good images. The best camera locations view longitudinally down the freeway lanes, near the traffic and without view obstructions. Some sites view too near to perpendicular across lanes to discern where a motor-cycle was in the lane, other cameras are too far away from the freeway, others have view obstructions such as freeway signs. One freeway site was monitored in person for 30 minutes from an overpass and passing motorcycles photographed (Figure 3).

The hours of data collection were intentionally biased toward the weekday morning and evening "rush hours" because the Hurt study data suggested that lane splitting is most likely in congested traffic. It was not possible to evaluate motorcycle lane position during hours of darkness from a video camera mounted along a freeway so no data were collected during those hours. Forty-nine percent (129 of 261 motorcycle) were observed in the morning between 7 – 10 a.m., and another 107 (41%) during the afternoon rush hours of 3 – 6 p.m. and the remainder within 30 minutes of those hours. Therefore, the data here do not reflect average around-the-clock lane splitting frequency; instead the data reflect what happens when traffic is heavy for at least one direction of freeway traffic.

Hurt study accident and exposure data

On-scene, in-depth accident investigation data were collected in 1976-77 under contract between the National Highway Traffic Safety Administration and the University of Southern California. After notification by police or fire department ambulance dispatchers, teams of specially trained investigators, went to each accident scene immediately after a crash in order to conduct an investigation and analysis independent of the police investigation. Team investigators documented vehicle and roadway conditions and physical evidence from the crash such as skid and scrape marks, collision damage, etc. by personal observation, photography and measurement. They interviewed riders, passengers, car drivers, eyewitnesses and so on. Helmets were obtained for examination and photography and injury data were obtained.

Each investigation entailed collection, analysis and encoding of approximately one thousand data elements. Some data elements were simple items such as weather, roadway type, motorcycle manufacturer or rider gender. Other items were complex factors that required considerable analysis and integration of accident evidence, such as precrash and crash actions and speeds, injury mechanisms and accident cause factors. In Los Angeles, data were collected only within the 462 square miles (1242 square km) of the City of Los Angeles, which is mostly urban and suburban, with a few semi-rural areas.

The only criterion for a crash to be included in the study was whether the team was able to collect enough information about the crash to have a complete investigation. There was no pre-selection for any particular accident or injury characteristic. The crash investigation and reconstruction methods have been described elsewhere in more detail (*3, 4*). They have since been adapted and incorporated into the OECD Common International Methodology for Motorcycle Accidents (*5*) and applied in Europe (*6*) and Thailand (*7, 8*).

The value of accident data is greatly enhanced if one knows how it compares to the larger population of riders exposed to accident risk by riding a motorcycle on streets and roads but *not* involved in a crash. Simply put, if accident data is considered a numerator, then exposure data is the denominator. In order to collect this "exposure data," USC investigators returned to the scenes of crashes at the same time of day and same day of the week as a previously investigated crash in order to count vehicle and motorcycle traffic passing by the scenes, photograph passing motorcycles and to speak with riders who voluntarily stopped for an interview.

Ideally, exposure data should be collected within days of the crash to assure similar conditions as much as possible. However, delays in funding forced the postponement of exposure data collection, so that exposure data were collected approximately one, two or even three years after the crash.

For this study, still photos of motorcycles that passed by the exposure data collection sites were examined and evaluated to identify general traffic density (light, medium, heavy) and the lane position of the motorcycles passing by the exposure site. Motorcycle lane position was classified into one of four categories: 1) lane splitting, 2) not lane splitting or 3) unable to determine (usually if the photo was too blurry or the view of the motorcycle was blocked by other traffic) or 4) not applicable, in cases where, for example, the motorcyclist was not in a regular traffic lane. Figure 4 illustrates some of these judgments. Data are reported here only for motorcycles in the first two of those categories. Also, all data reported here are for freeway "mainline" roads – the primary travel lanes of the freeway. "Mainline" excludes on-ramps, off-ramps, combined on-off ramps or lanes and transition ramps from one freeway to another.

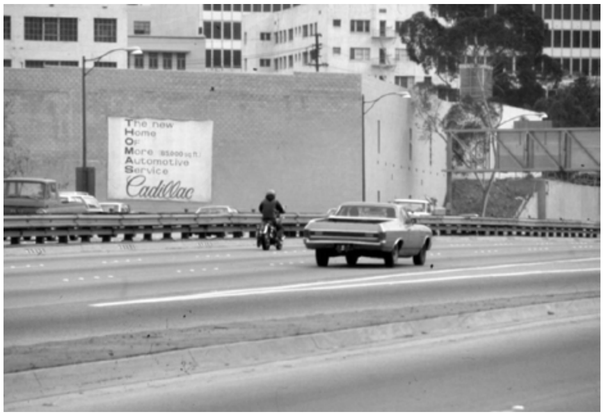

Figure 4a. Light traffic, normal lane position.

Figure 4b. Heavy traffic, lane splitting.

Figure 4c. Heavy traffic, normal lane position, following too closely.

Figure 4d. Heavy traffic, normal lane position, following too closely.

Figure 4e. Heavy traffic, lane splitting.

Figure 4f. Heavy traffic, lane splitting.

Statistical Analysis

Cases in which one of the variables under consideration was unknown were eliminated from analysis. As a result, the number of riders may vary slightly from one comparison to another. The tables presented in this paper may include data only for the presence of a factor since simple math will yield the proportion of riders with “absence” of that factor. A two-tailed probability less than .05 is assumed to be statistically significant.

RESULTS

Exposure data, 2011

Monitoring real-time video feeds in northern California urban areas at the evening rush hour (US 101 at Bayshore in San Francisco, I-80 at Ashby in Berkeley and US-50 at 9th Street in Sacramento) showed that, overall, 40 of 107 motorcycles (37%) were splitting lanes when observed. However, when traffic was congested and moving slowly, 37 of 56 (66%) were splitting lanes, compared to 3 of 51 motorcycles (6%) when traffic was moving at closer to free-flowing freeway speeds ($\chi^2 = 41.3$, df = 1, $p < .001$). It was common for traffic to be congested in one direction and flow freely in the opposite direction at the same time, as Figures 2 and 3 suggest. Speed data were not available at these sites.

Still photos of motorcycles observed on Los Angeles freeways during weekday “rush hour” traffic conditions showed that overall, 55% of motorcycles were lane-splitting. As Figure 5 suggests, the likelihood a motorcycle would be observed splitting lanes varied depending on congestion and average traffic speed.

Figure 5 illustrates the relationship between average traffic speeds and lane splitting frequency. The likelihood of lane splitting declined gradually as speeds increased up to 40 mph, then dropped sharply. At speeds below 20 mph (33 km/hr), 83% of observed motorcycles were splitting lanes, but when traffic speeds exceeded 50 mph (80 km/hr) only about 10% of motorcycles were observed splitting lanes.

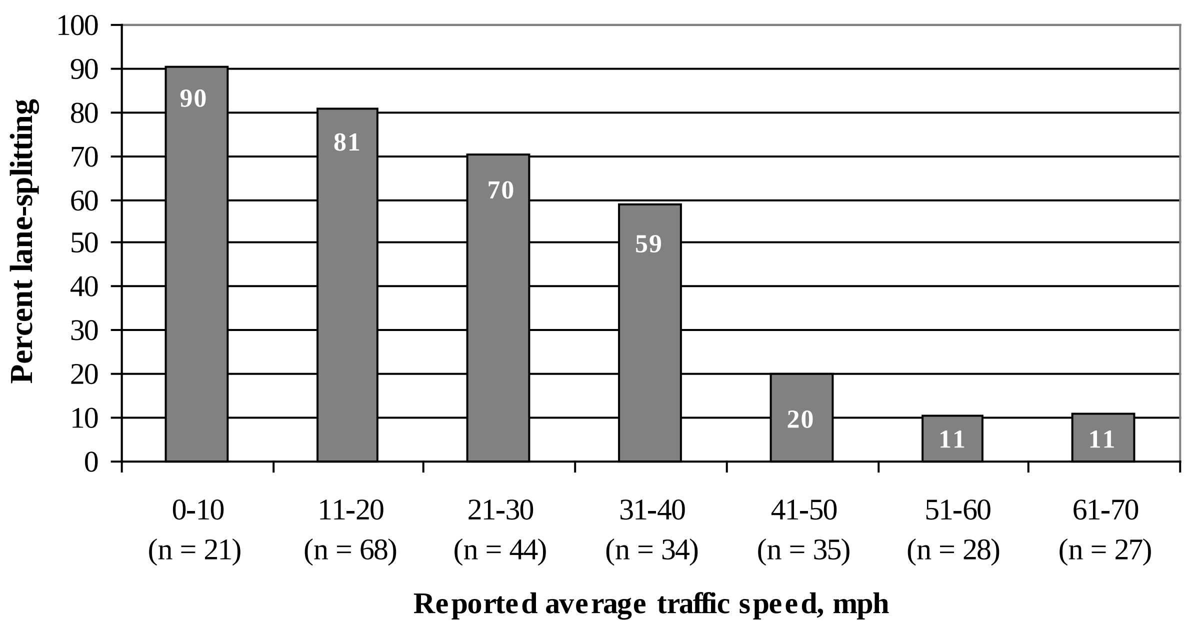

Figure 5. Percentage of motorcycles splitting lanes as a function of average traffic speed.

On the freeways where the 2011 exposure data were collected, motorcycles were overwhelmingly likely to be in the two lanes closest to the center divider. Still photos of Los Angeles freeways showed that ninety-one percent of the motorcycles observed lane splitting (128 of 140) were riding between lanes 1 and 2 (counting outward from the center divider), while 92 of the 114 motorcycles (81%) riding in a normal lane position were in either the #1 or #2 lanes.

Exposure data, 1970s

Exposure data were collected at only 505 of the 900 accident sites. On freeway mainlines, heavy traffic was reported in 24 of the 61 accidents and exposure data was located for 11 of those 24. However traffic was again heavy at only three of those 11 exposure sites where traffic had been heavy at the time of the crash. Traffic was moderate at four, light at one and no photos were available at three. Data were therefore analyzed from eight additional freeway exposure sites where traffic had been light or moderate at the time of the crash. All of those additional eight cases showed either light or moderate and traffic during the exposure data collection. Table 1 shows the traffic density conditions at the time of the accident and exposure data collections.

Table 1. Freeway traffic density at time of accident and during exposure data collection

Exposure Traffic Density	Traffic Density at Time of Accident			Total
	Light	Moderate	Heavy	
Light	1	5	1	7
Moderate		2	4	6
Heavy			3	3
No data			3	3
Total	1	7	11	19

At the 19 freeway exposure sites available for review, lane splitting was observed almost exclusively in heavy traffic conditions, during which 24 of 38 motorcycles (63%) photographed by investigators were splitting lanes compared to only four of 150 motorcycles (3%) splitting lanes in moderate traffic, a difference that was statistically significant ($\chi^2 = 87.5$, df = 1, $p < .001$).

Freeway accidents, 1976-77

Sixty-one crashes occurred on freeway mainlines (a category that excludes onramps, off-ramps, combined on-off ramps or lanes and transition roads.) Of those, 38 involved another vehicle, usually by direct contact, but in three cases the motorcycle crashed while trying to avoid another vehicle violating its space. Of the 38, seven occurred in light traffic, 11 in moderate traffic and 20 in heavy traffic. Figure 6 shows the distribution of conditions for the 61freeway mainline crashes.

Only five of the 900 crashes (0.6%) reported by Hurt et al. (*2*) involved a motorcycle that was late-splitting just before the crash. Four of these occurred on a freeway mainline. All occurred in heavy traffic and most at speeds below the 55 mph speed limit that was in effect from 1974-1995. Three of the four occurred when the other vehicle (OV) changed lanes across the motorcycle path. One lane-splitting crash occurred on surface streets when the rider checked over his shoulder and struck the rear of a car.

By comparison, ten motorcycles that were maintaining a normal lane position crashed in heavily congested freeway mainline traffic and another nine crashed in moderately congested traffic. That is, lane-splitting motorcycles were four of fourteen crashes (29%) in heavy freeway mainline traffic and zero of nine that occurred in moderate traffic.

In the 1970s exposure cases, 38 motorcycles were observed in heavy freeway traffic. Twenty-three of those (63%) were splitting lanes when they were observed, while 15 were maintaining normal lane position. The distribution of lane splitting versus normal lane position in accident and exposure cases involving heavy traffic is illustrated in Figure 7.

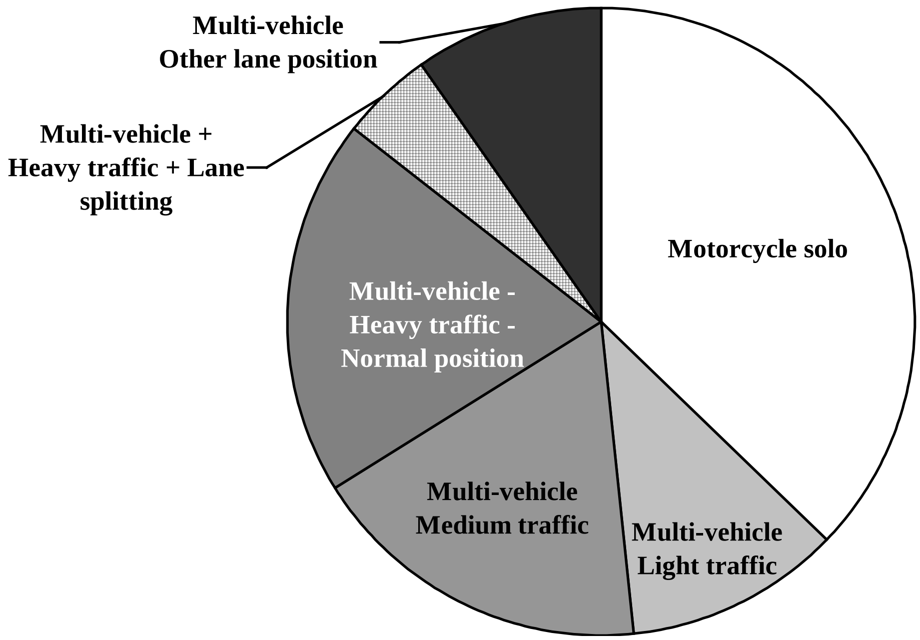

Figure 6. Distribution of 61 freeway mainline accidents

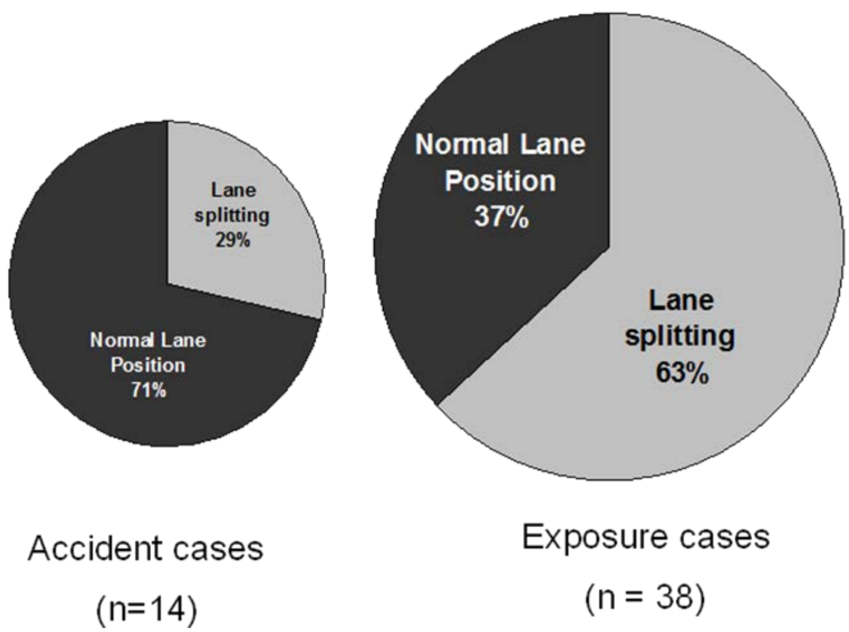

Figure 7. Comparison of lane position of motorcycles in heavily congested freeway conditions in accident and exposure cases.

Figure 7 shows that lane splitting motorcycles were under-represented in crashes (29%) compared to their percentage (63%) observed in heavy traffic on the roads. A Fisher exact test yields a two-tailed probability of this result at 0.033. This means that riders maintaining a normal lane position in heavy freeway traffic were significantly over-represented in crashes while those who were lane splitting were under-represented.

The motorcycle was known to be either lane splitting or in a normal location in 25 of the 31 crashes that occurred during moderate or heavy traffic conditions. The speed of both vehicles before any evasive action was known for 23 of those 25 crashes. The diagonal line indicates equal speeds of the two vehicles; data points below the diagonal line indicate a motorcycle speed greater than the speed of the other vehicle involved in the crash. It is no surprise that in most cases the precrash speed of the motorcycle and other vehicle are very close, though the motorcycle speeds generally tended to be higher than the OV speed. The median precrash motorcycle speed in moderate traffic was 55 mph; in heavy traffic it was 34 mph for motorcycles in a normal lane position, 40 mph for lane splitters.

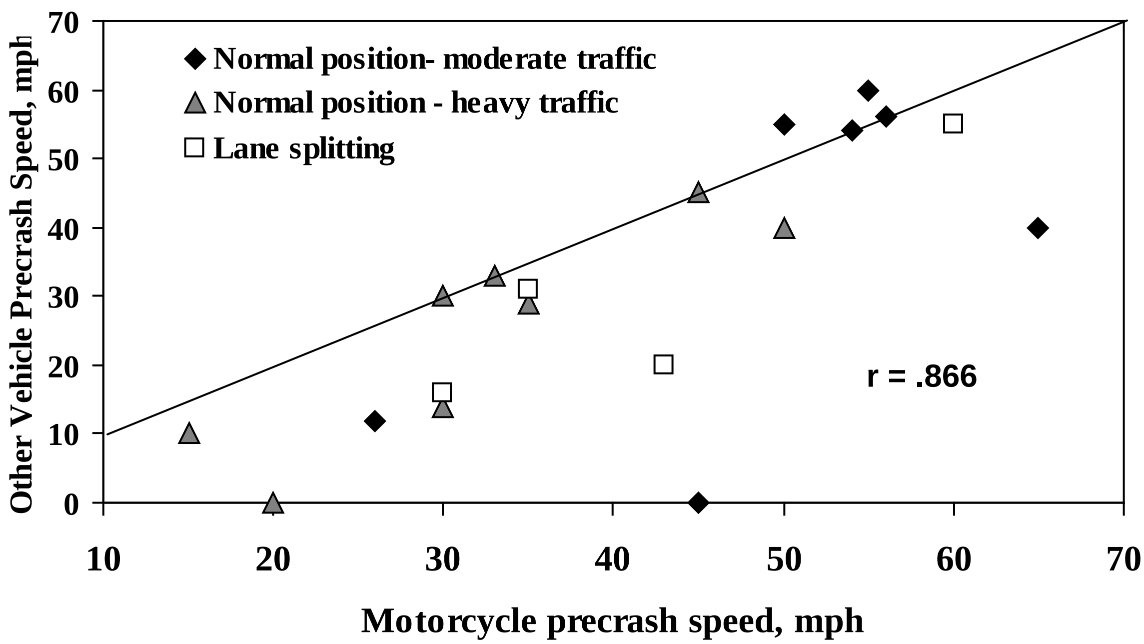

Figure 7. Scatter-plot of precrash speeds of motorcycles and collision partners. The diagonal line portrays where both vehicles were going the same speed.

Table 2 shows a crosstabulation of the other vehicle (OV) precrash motion by the collision configuration for the fourteen freeway crashes in heavy traffic. In all four lane splitting crashes, the motorcycle was going faster than the other vehicle when the two vehicles sideswiped each other. In three of the four lane splitting crashes, the other vehicle changed lanes across the motorcycle path; in the fourth the rider sideswiped the other vehicle although it was not making a lane change.

By comparison, when the motorcycle was in a normal lane position at least one third of the crashes involved the other vehicle changing into the motorcyclist's lane (perhaps as many as half, if the cases in which the motorcycle crashed trying to avoid collision with the other vehicle also involved lane changing cars.) In another one-third of crashes the motorcycle rear-ended the car ahead of it.

Table 2. Accident configuration by OV precrash motion in heavy freeway traffic. Data for lane splitting motorcycles is in parentheses.

Accident Configuration	**Other Vehicle (OV) Precrash Motion**					**Total**
	Moving Straight	Overtaking	Slowing	Stopped	Lane change	
MC strikes OV rear end	2		1	1		4
Same direction sideswipe	(1)	1			2 (3)	3 (4)
Other MC-OV crash, not coded				1		1
MC fell or ran off road to avoid OV			1		1	2
Total	2 (1)	1	2	2	3 (3)	10 (4)

DISCUSSION

The principal findings of this study are: 1) the likelihood of motorcycle lane splitting decreases as freeway speeds go up and the decline appears to be especially marked at speeds above 40 mph (66 km/hr). 2) The conditions under which splitting occurs and the frequency of lane splitting appear to be roughly the same in 2011 compared to the late 1970s; 3) lane splitting crashes appear to be a tiny portion (less than 1%) of the motorcycle accident population. 4) In the 1970s, lane splitting riders were under-represented in crashes compared to their frequency in traffic and the difference was statistically significant.

In heavily congested freeway traffic conditions, 63% of motorcycles were splitting lanes in the late 1970s, compared to 66% seen lane-splitting on live-feed video cameras in 2011. Using still photos of motorcycles in traffic on Los Angeles freeways in 2011 suggests that the likelihood of lane splitting exceeds 80% for average traffic speeds below 20 mph (35 km/hr, and drops to about 10% when speeds exceed 50 mph (80 km/hr).

The simple fact that only five of 900 crashes (0.6%) involved a motorcycle splitting lanes suggests that lane splitting is simply not a great problem in the overall population of motorcycle crashes. Perhaps it is simply coincidence, but more than 25 years later, nearly identical results were reported in Europe for the Motorcycle Accident In-Depth Study (*6*) of 923 motorcycle accidents: only 4 crashes (0.4%) occurred when the motorcycle was splitting lanes. That is, lane splitting made a trivial contribution to the motorcycle accident population in both Los Angeles (late 1970s) and Europe (1999-2000). In Los Angeles, more than three times as many crashes were caused by roadway defects (n = 18) or pedestrians and animals (n = 16) than the five lane-splitting collisions.

Lane splitting can appear to be a risky maneuver, but the data presented here suggest that riders who split lanes, at least on freeways, are significantly **less** likely to be involved in a crash than riders who maintain a normal lane position. To put it more simply, the data suggest that splitting lanes may be safer than NOT splitting lanes. If this finding is valid – a caution worth keeping in mind because of the small number of cases available for study – then laws that effectively ban motorcycle lane splitting may have the unintended effect of increasing motorcycle crashes.

If lane splitting is safer than maintaining a normal lane position, several factors might explain that. First, as Table 2 shows, maintaining a normal lane position does not prevent cars from suddenly veering into the space occupied by the motorcycle. Car drivers fail to see motorcycles and veer across the motorcycle's path and they do it whether the motorcycle is lane-splitting or in a normal lane position. As with most types of motorcycle-car crashes, the biggest problem is car driver failure to see a motorcycle, not the lane position of the motorcycle. In addition, rear end collisions account for a significant minority of crashes for motorcycles that are not lane splitting, and Figure 2 suggests why this might be the case: motorcyclists following too closely behind the vehicle ahead.

A second reason that lane splitting may be safer than maintaining a normal lane position is that it is the rider who makes the decision whether to proceed into a situation where a crash could occur. Since punishment for a bad decision will be immediate and painful, riders apparently tend to make fairly good decisions. By comparison, a rider maintaining a normal lane position has no ability to affect whether a car in an adjacent lane will intrude into the motorcycle's space. The motorcyclist is entirely reliant on the car driver's vigilance and judgment – a vulnerability at the heart of the great majority of motorcycle-car crashes.

CONCLUSIONS

It is clear that lane-splitting contributes little to the population of motorcycle accidents – less than 1% both in Los Angeles in 1976-77 and a quarter century later and a continent away in Europe in 1999-2000. Eliminating a ban on lane splitting is unlikely lead to an increase in motorcycle accidents.

If the intent of banning motorcycle lane splitting is to protect motorcyclists, the data presented here fail to support that justification. In fact, these data suggest that lane splitting is safer than maintaining a normal lane position. There are three reasons lane splitting may be safer than riding in a normal lane position:

1. Maintaining a normal lane position does nothing to eliminate sudden path encroachment by cars. Motorcyclists are vulnerable to incautious car drivers making sudden, unsignaled lane changes regardless of the motorcycle position in the lane.
2. In heavy traffic conditions where lane splitting usually occurs, the motorcyclist has the option to decide which risks to take and it is often clear which traffic conditions are safe (cars in adjacent lanes side-by-side) or risky (a gap in an adjacent lane big enough for a car to move into.)
3. Motorcycles in a normal lane position are far more likely than those splitting lanes to be involved in rear-end collisions, usually because the motorcycle is following too closely behind a car ahead.

RECOMMENDATIONS

California has the potential to contribute large amounts of both accident and exposure data regarding the relative risk of lane splitting. To collect accident data, the California Highway Patrol traffic collision report Form 555, page 2, could add a code for "motorcycle lane splitting" to the coding choices of either the "Movement Preceding Collision" or "Special Information" categories. At the same time, exposure data on lane splitting can be collected from the video cameras that constantly monitor traffic conditions on California urban freeways. Counting motorcycles and identifying their lane position could be done by individuals monitoring video or by developing a computer program that can do the same job.

ACKNOWLEDGMENTS

The author is indebted to Dr. Hugh Harrison Hurt III and the Head Protection Research Laboratory for assistance in compiling and verifying the accuracy of the data and the use of exposure data for comparisons. The author is always indebted to the late Professor Hugh Harrison Hurt, Jr.

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