A preliminary look at safety critical events from the motorcyclists' perspective

by

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Abstract

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Crash reports and injury statistics have long been important outcome variables in the study of motorcyclists and the success of the training they receive. Yet, for many researchers, these indicators have not been an adequate indicator of success. Specifically, Simpson & Mayhew (1990) warned researchers of the pitfalls of evaluating the effectiveness of motorcycle rider training through considering only final outcomes and by not considering the rider's perspective. Instead, they noted researchers should look further into mediating variables and their effects upon those final outcomes. Also, investigators should evaluate the value of training from the students' perspective.

Studying near crash scenarios provided by riders meets these criteria. In hazardous situations such as traffic crashes, near crash scenarios can improve knowledge of a rider's response to an actual crash scenario. This type of crash surrogate measure has been shown to be useful in traffic safety analysis. As these scenarios share a similar chain of events with actual crashes, understanding them may help us to better understand motorcycle crashes and the external circumstances surrounding them. These events have been called "Safety critical events" and can be defined as an event where a rider has to take immediate evasive action to avoid a crash or to correct for unsafe acts performed by the rider himself/herself or by other road users. Safety critical events have never been described and categorized for motorcyclists.

Participants were enrolled in a larger study at the California Motorcyclists Safety Program (CMSP)-recognized Discovery Rider Training Center (DRTC) in Long Beach, California. Study participants who passed their BRC were asked to return to the DRTC for follow-up visits occurring approximately 3, 6, 12, and 18 months after completion of their initial BRC. At each follow-up visit all participants were asked to complete a Motorcycle Study Questionnaire (MSQ).

The 37-item Motorcycle Study Questionnaire (MSQ) was self-administered and was used to obtain information about motorcycle use and riding experience, motorcycle crashes, near misses (also called near crashes), traffic tickets, rider demographics, and various measures of motorcycling attitudes and riding behaviors. Written descriptions of near crashes came from participants in this longitudinal study. Completion of the MSQ instrument provided a sample of 778 near crash incidents reported by all participants in the study.

Narratives were coded for crash situation, near crash type, rider action taken, and inclusion of a safety or training concept. The content of the near crash scenarios were analyzed using a content analysis protocol. Overall a large percentage of the course participants reported no incidence of safety critical events. In addition, the nature of the near crashes described by participants is multiple vehicle events where another vehicle incurs into the path of the motorcycle. Rider responses, when provided, tended to be either braking or swerving. The results of this analysis provide an initial look at what types of situations arise for motorcyclists and what their self-reported responses are.

Introduction

Crash reports and injury statistics have long been important outcome variables in the study of motorcyclists and the success of the training they receive. Yet, for many researchers, these indicators have not been an adequate indicator of success. Specifically, Simpson & Mayhew (1990) warned researchers of the pitfalls of evaluating the effectiveness of motorcycle rider training through considering only final outcomes and by not considering the rider's perspective. Instead, they noted researchers should look further into mediating variables and their effects upon those final outcomes. Additionally, researchers should consider capturing measurements of variables that go beyond violation and crash statistics. Variables such as self-reported cases of utilizing crash avoidance skills, the severity of collisions, improvement of riding skills, using protective gear, and attitudes towards safety may serve as important outcomes. Also, investigators should evaluate the value of training from the students' perspective.

Anecdotal evidence from Motorcycle Safety Foundation training course participants abounds that reports the use of various crash avoidance skills and riding strategies in on-road riding. Yet, these countless narratives have not been represented in the study variables.

Studying near crash scenarios provided by riders meets these criteria. In hazardous situations such as traffic crashes, near crash scenarios can improve knowledge of a rider's response to an actual crash situation. This type of crash surrogate measure has been shown to be useful in traffic safety analysis. As these scenarios share a similar chain of events with actual crashes, understanding them may help us to better understand motorcycle crashes and the external circumstances surrounding them. These events have been called "Safety critical events" and can be defined as an event where a rider has to take immediate evasive action to avoid a crash or to correct for unsafe acts performed by the rider himself/herself or by other road users. Safety critical events have never been described and categorized for motorcyclists.

Background

Motorcyclist fatalities have been rising steadily since the 1990's – with the US total reaching a new high mark in 2007. Motorcycles and scooters comprise less than 4% of all vehicles on the road, However, in recent fatality statistics, motorcyclists account for nearly 15% of highway fatalities (NHTSA, 2012). This overrepresentation has been associated with an uptick in research.

Yet, given this steep increase, the individual motorcycle crash is still a relatively rare event. It is not surprising, then, that the majority of our information about motorcycle crashes and their causes mostly stems from crash data bases that are derived from crash causation studies or state-based reporting systems. In crash causation studies, causation is determined from a wide range of variables taken from pre and post-crash events and are many times based on investigation of the crash scene. Narrative accounts from the involved motorcyclists are called for as part of the study database, but, collecting these is not always possible due to rider injury status. In addition, large scale crash causation studies generally limit the crashes studied to injury crashes. Thus, these type of near incidents or safety critical events are not included in the analysis. Databases based on state reports are most often based on police reports. National crash databases used most often to understand crash causation and problematic issues are generally based on fatal crashes only. Again, these type of near crash situations are not a part of the national crash databases.

Given the rarity of motorcycle crashes, the expense of full scale crash causation studies and the lack of generalizability of studying fatal-only crashes, some researchers have used crash surrogates as a way of studying potential crashes. Studying near misses, one crash surrogate measure, as safety critical events is considered a learning opportunity where lessons can be learned that will improve safety in the future. For example, examining near miss scenarios is common in a medical context. In a traffic context, both the maritime and aviation industries require incident reporting, not just crash reporting, in order to learn about safety issues in their fields (Hardy, 2009). A study looking at pedestrian near miss events used Time to Collision as an indicator of a safety critical event. Evidence for this determination was taken from the video record in the vehicle involved in the vehicle-pedestrial interation.

Bagdadi (2013) referred to near misses as safety critical events defining them as “ . . . situations that requires a sudden, evasive maneuver by the subject vehicle, to avoid a hazard or to correct for unsafe acts performed by the driver himself/herself or by other road users”. Safety critical events, however, have never been described and categorized for motorcyclists. This is the case despite of the fact that in the everyday driving, near-misses are much more common than are accidents (DeJoy and Klippel, 1984). Clearly, understanding more about such events can have a positive influence on safety related efforts.

Previous research has focused primarily on crash causation. The seminal Hurt report (1981) found that human errors were the primary accident contributing factor, suggesting that vehicle operators are largely responsible for accident causation. The notion that vehicle operators could also be responsible for crash avoidance as well should not be ignored. Safety critical events, therefore, represent an area of exploration that could prove valuable for decision makers.

Crash surrogates, defined through vehicle kinematics, are used in naturalistic data reduction as a method of identifying safety critical events such an lane departures, yaw rate error or steering rate threshold (McLaughlin, Hankey, Klauer & Dingus, 2009) .

Elliott, Baughan, and Sexton (2007) found that riders having a higher level of self-reported traffic errors tended to have an increased likelihood of “all crashes” than did those who reported committing traffic errors less often. All crashes was defined as those occurring during the last 12 months and "blamecrashes" were identified as crashes in which the rider accepted some degree of blame.

In assessing the relevance of safety critical events, the U.S. Department of Transport, Research and Innovative Technology Administration (RITA) reported that

> Virtually all transportation accidents are preceded by a chain of events or circumstances—any one of which might have prevented the accident if it had gone another *way. In a large number of cases, operators are aware of these "close calls" or "near misses" and may have information that could prevent future accidents. However, most of our modal programs are focused on collecting data on mishaps only when they result in a reportable accident. This leaves unexposed the large majority of cases where we could develop useful data on accident precursors or on prevention strategies that have actually worked (…)".*

Crash surrogates are also important since they have found to be statistically related to and predictive of subsequent crash events. Based on a large sample of motorcycle riders in the UK, Sexton, Baughan, Elliot, & Maycock (2004) found that self-reported errors were the most important behavioral contributors to accident involvement (after controlling for mileage). They argued that the link between these errors and accidents may be as much to do with a careless inattentive riding style and excessive speed as it is with lack of skill. Traffic errors (mostly associated with failures of hazard perception or observational skills) were the most consistent predictors. Control errors (mainly to do with difficulties of control associated with high speed, or errors in speed selection) were also important. Riding style and a liking for speed were identified as predictors of behavioral errors (that were themselves predictors of crashes). Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations that lead people to ride motorcycles in the first place, and presents a challenging problem for road safety. Studies have shown a correlation between crash surrogate measures such as critical braking events and the incidence of crashes (Bagdadi, 2013). Thus, it is a reasonable thing to measure – crash surrogates can help us identify riders at higher risk of crashing.

In specific regard to rider education and training the *National Agenda for Motorcycle Safety* (2000) recommends that programs be based on a "uniform, educationally sound curricula that reflects current crash and training research as well as the differing demands of various riders and environments" (p. 18). Crash avoidance skills are important components of rider education and training curricula. According to the National Agenda, research identified braking, cornering, and swerving as crash avoidance skills absent among crash-involved motorcyclists. It is unknown if the lack of these skills continues to be over-represented in crash data, or if other deficiencies or behaviors play larger roles in today's crashes. The National Agenda provides five recommendations addressing crash avoidance skills: 1) Conduct research to determine which rider crash avoidance skills are most important, 2) Develop countermeasures in training, license testing, and motorcycle technology to address any current crash avoidance deficiencies, 3) Evaluate the effectiveness of entry-level rider education and training in developing crash avoidance skills, 4) Evaluate the need for motorcycle simulator skills training, and 5) Examine technological approaches such as pre-crash warning and avoidance systems to enhance crash prevention. The present study is an evaluation of training in crash avoidance skills as well as a new approach to rider education and training that was developed based on this recommendation to improve the way novice motorcyclists are trained and educated beyond simple, basic entry-level training.

Method

Participants

Participants were enrolled beginning in January 2008 and ending in September 2010. Individuals who enrolled in a Basic RiderCourse at the California Motorcyclists Safety Program (CMSP)-recognized Discovery Rider Training Center (DRTC) in Long Beach, California were recruited to participate in a larger study investigating the effects of safety renewal at the end of their first session of classroom instruction. Those who expressed interest in participating and completed informed consent forms were randomly assigned to the RETS or BRC-Only conditions in a manner that was blind to study participants.

Materials

Motorcycle Study Questionnaire (MSQ)

The 37-item Motorcycle Study Questionnaire (MSQ) was self-administered at enrollment and each follow up visit. The MSQ was adapted from the questionnaire used by Sexton, Baughan, Elliott, and Maycock (2004). It was used to obtain information about motorcycle use and riding experience, motorcycle crashes, near misses, and traffic tickets, several measures of motorcycling attitudes and riding behavior, rider demographics, and other issues The MSQ was pilot-tested prior to full-scale deployment to ensure the items were clear and response options appropriate for individuals enrolled in the BRC. The results were used to refine the questionnaire and administration procedures. MSQs were mailed to study participants at least one week prior to each scheduled follow-up visit, though additional copies were available on-site during the follow-ups, and collected from riders when they returned to the DRTC. The MSQ provided measures of several intermediate outcomes (e.g., use of safety equipment/gear and self-assessed riding skill) and covariates (e.g., recent riding exposure and prior formal motorcycle training experience) for the study.

Analysis

Coding Procedures

Inductive content analyses were performed on a subsample of 100 near crash descriptions. The analyses of the descriptions were performed in five steps: (1) independent development of content categories for each of the variables, (2) discussion aimed at obtaining consensus categories, (3) creation of a manual with coding rules and defining criteria for categories and subcategories, (4) assessment of inter-rater reliability to identify unreliable categories to be revised, and (5) repetition of inter-rater reliability assessment.

Narratives were coded for crash situation, near crash type, and rider response.

Sampling Plan

A total of 4804 Motorcycle Safety Questionnaires were completed during the data collection phase of the Discovery Project. Of this total sample, nearly 83% listed no "near miss" experience during the previous three months of riding. Just over 17% of the sample indicated one or more near miss experiences during their previous three months of riding.

Table 1
How many times have you experienced a near miss in the last 3 months while riding a MOTORCYCLE on a public road?

	Frequency	Percent
Never	3971	82.7
On 1 or 2 occasions	696	14.5
On 3 to 5 occasions	105	2.2
On 6 to 10 occasions	23	0.5
On more than 10 occasions	9	0.2
Total	4804	

Of the 833 participants who noted they had experienced one or more safety critical or near miss incidents, 54 gave no follow-up description as requested in the subsequent question. These blank responses were not included in the sample. In addition, as noted in the following section, 93 individual descriptions were judged to be generic and were also dropped from the sample. The remaining 686 descriptions made up the final sample.

Units of Analysis

The near miss description was considered to be the unit of analysis. Topics or ideas were coded from each unit to represent the variables of interest including, number of vehicles, crash type, motorcyclist's primary and secondary response, and inclusion of a traffic safety concept.

Inductive Category Development

The two researchers began with a random sample of one hundred near miss descriptions. From these descriptions, they derived crash type, motorcyclist response, and traffic safety inclusion coding categories through an inductive process, noting each unique instance. Several additional categories were added as a result of the reliability analysis (results noted below.) Table 2 contains a complete list of categories used for each variable of interest along with an exemplar of each category from the descriptions.

Table 2

Coding Scheme for Crash Type, Action Taken, Traffic Safety Concept Inclusion

Near Crash Type

1. Vehicle turns left into motorcycle path
2. Vehicle pulls into motorcycle path from right (at intersection)
3. Vehicle entering motorcycle lane from right (other than intersection)
4. Vehicle changes lanes into motorcycle path/lane (both vehicles moving)
5. Vehicle merges into motorcycle path/lane (both vehicles moving) (If word merge is not used, we'll assume lane change)
6. Opposing traffic enters motorcycle path/lane (crosses yellow line)
7. Obstacles in motorcycle path/lane
8. Motorcycle lane sharing
   81 Vehicle in or entering motorcycle path
   82 Other vehicle squeezing motorcycle path
   83 Motorcycle hitting other vehicles
9. Motorcycle loss of control
   91 Road surface conditions
   92 Motorcycle speed
   93 Other Single Vehicle
10. Vehicle ahead slows/stops suddenly
11. Vehicle from behind not slowing
12. Pedestrians entering traffic lanes
13. Animals in traffic
14. Generic car pulls out/"cuts me off"
15. Misc.

Action Taken

1. Accelerate
2. Brake
3. Swerve
4. Downshift
5. Decelerate
6. Leave roadway
7. No action taken
8. Change lanes
9. Change lane position
10. Honk the horn
11. Adjusted lean angle (Single vehicle cornering)

Traffic Safety Concept

1 =

- Mentions BRC course concept, technique or makes traffic safety reference
- Shows self-reflection or safety related insight: e.g. – "could have", "should have"
- Indicates future change in behavior: e.g. – "next time"

Reliability Analysis

Using this initial set of categories, the two researchers coded a unique random sample of fifty descriptions (different from the initial sample used for category development). An interrater reliability analysis was performed to determine consistency between raters.

Two coders discussed coding categories for each variable to enable clarity of definitions. Terms such as “merge” and “path or lane” were distinguished from others such as “enters” or ”pulls into.” During the inductive category development phase, researchers identified 93 descriptions that were considered to be “generic,” where no specific near crash or safety critical incident was described. Rather, the participant made a general statement regarding other vehicle operators or the road in general. For example, one participant noted, “People pulling out while lane splitting.” Another noted, “Car switching lane - watch for blind spots, soccer moms and high powered Mercedes. Tailgating - Flash break lights.” These units were dropped from the sample as they did not describe an actual near miss.

The initial coding session of 25 randomly selected descriptions, resulted in a interrater reliability of Kappa = .95 for Near Crash Type; Kappa = .79 for Primary Rider Response; Kappa = 1.0 for Secondary Rider Response; and .65 for Traffic Safety Concept Inclusion. Following the discussion to clarify categories for Traffic Safety Concept Inclusion, the two coders separately coded an additional random sample of 25, which resulted in lower interrater reliability estimates for Near Crash Type (Kappa = .64), Primary Rider Response (Kappa = .87), Secondary Rider Response (Kappa = .62), and Traffic Safety Concept Inclusion (Kappa = .67). The two coders engaged in additional category definition discussions and drew a third random sample of 25 descriptions. On a third random sample, the two coders were able to achieve high interrater reliability estimates for all variables: Near Crash Type (Kappa = .84); Primary Rider Response (Kappa = .94); Secondary Rider Response (Kappa = .88); Traffic Safety Concept Inclusion (Kappa = .74). For Cohen's kappa 0.60 is set as a minimum requirement (Landis & Koch, 1977).

Results

There is a significant association between visit number and reporting a near miss incident. For this analysis, the first visit (the BRC class) is not reported, since according to historical records, only 30% of BRC participants have some experience riding while the remainder has had no experience with a motorcycle or scooter. Across both groups, the numbers of near miss incidents decreased over the time of the repeat visits. A Chi Square analysis shows a significant relationship between the two ordinal variables using a linear-by-linear association measure (Association = 6.20; p = .013) or a Somers'd calculation (Somers'd = -.054; p = .016).

How many times have you experienced a near miss in the last 3 months while riding a MOTORCYCLE on a public road? By Visit #						
		Visit#				Total
		2	3	4	5	
Never	Count	362	230	183	137	912
	% within Visit#	58.11	59.43	64.21	66.50	60.76
On 1 or 2 occasions	Count	219	123	83	61	486
	% within Visit#	35.15	31.78	29.12	29.61	32.38
On 3 to 5 occasions	Count	30	27	16	6	79
	% within Visit#	4.82	6.98	5.61	2.91	5.26
On 6 to 10 occasions	Count	8	5	2	2	17
	% within Visit#	1.28	1.29	0.70	0.97	1.13
On more than 10 occasions	Count	4	2	1	0	7
	% within Visit#	0.64	0.52	0.35	0.00	0.47
	Count	623	387	285	206	1501

Number of vehicles. Across the near miss descriptions, 89% were descriptions of multiple vehicle incidents while only 11% described a single vehicle event.

Crash type. Table 3 illustrates the distribution of near crash incident descriptions across the coded crash types. The most frequent near crash event involved another vehicle changing lanes into the path of the motorcycle while both vehicles were moving followed by the generic "car pulls out". The top seven categories are all multiple vehicle scenarios, with the first single vehicle category being loss of control due to speed.

Table 3

	Near Crash Type	Frequency	Percent
4	Vehicle changes lanes into mc path or lane (both vehicles moving)	207	30.2
14	Generic car pulls out or "cuts me off"	79	11.5
10	Vehicle ahead slows or stops suddenly	56	8.2
3	Vehicle entering mc lane from right (other than intersection)	55	8.0
1	Vehicle turns left into motorcycle path	53	7.7
2	Vehicle pulls into mc path from right (at intersection)	49	7.1
5	Vehicle merged into mc path or lane (both vehicles moving)	31	4.5
92	MC loss of control - MC speed	28	4.1
81	MC lane sharing - vehicle in mc path	27	3.9
11	Vehicle from behind not slowing	19	2.8
15	Miscellaneous	18	2.6
91	MC loss of control - Road surface conditions	17	2.5
93	MC loss of control - Other single vehicle	15	2.2
6	Opposing traffic enters mc path or lane (crosses yellow line)	11	1.6
7	Obstacles in mc path or lane	7	1.0
83	MC lane sharing - MC hitting other vehicles	7	1.0
12	Pedestrians entering traffic lanes	4	.6
13	Animals in traffic	2	.3
82	MC lane sharing - Other vehicle squeezing mc path	1	.1
	Total	686	100.0

Primary rider response. Table 4 illustrates the distribution of rider responses. The primary response was defined as that description that was entered first, if the respondent listed more than one response. Though the survey question asked for a description of the event and the rider's response, over one quarter of the near miss descriptions contained no mention of a rider response. The most frequently occurring response was to brake, with 30% of the respondents citing this as their primary response. The swerve maneuver was reported in the description by 16% of the sample. The third most prevalent response, No Action Taken, was coded when the respondent specifically noted that they had made no crash avoidance or other maneuver.

Table 4 Primary Rider Response	Frequency	Percent
Brake	206	30.0
No Rider Response mentioned	169	24.6
Swerve	115	16.8
No action taken	42	6.1
Decelerate	31	4.5
Honk the horn	28	4.1
Change lanes	27	3.9
Accelerate	22	3.2
Change lane position	15	2.2
Adjusted lean angle	13	1.9
Downshift	9	1.3
Leave roadway	9	1.3
Total	686	100.0

Secondary Rider Response. Table 5 contains the results for Secondary Rider Response. Less than 30% of the sample indicated a secondary response. Of those who did, the most frequent response was braking, following by a swerve maneuver.

Table 5 Secondary Rider Response	Frequency	Percent
No Rider Response mentioned	503	73.3
Brake	51	7.4
Swerve	45	6.6
Change lanes	25	3.6
Honk the horn	16	2.3
Change lane position	14	2.0
Accelerate	10	1.5
Downshift	9	1.3
Decelerate	5	.7
Adjusted lean angle	5	.7
Leave roadway	3	.4
Total	686	100.0

Traffic Concept Cited. Table 6 indicates the percentage of respondents who cited a traffic safety or a Basic RiderCourse concept in their description. Nearly 35% of the sample referenced a strategy or concept that would have been helpful in this situation or one that should have been utilized. An example is, "Car came across double yellow line from diamond lane on fwy – Had anticipated drivers move and had an out to the right." Others indicated concepts or trips that would have been emphasized in the class such as "I applied rear and front brakes." Or "Thank you MSF!!"

Table 6

Traffic Concept Cited	Frequency	Percent
Yes	238	34.7
No	448	65.3
Total	686	100.0

Motorcyclists Error Indicated. Table 7 shows a distribution of the instance where coders identified a clear motorcyclist's error. These self-report descriptions gave infrequent indications of rider error – making up less than 10% of the descriptive accounts.

Table 7

Motorcyclist Error Indicated	Frequency	Percent
Yes	46	6.7
No	640	93.3
Total	686	100.0

Conclusion

Near crash (or near miss) events, like crashes, are uncommon events. However, even in this self-report data, they are much more common than crashes. As such, they are a way to understand pre-cursors to crash events. While over 15% of the participants experienced one or more near crash events, those participants who reported more than 1 or 2 events, made up a very small percentage of the sample.

In several significant ways, the self-report data mirrors what is found in the crash causation studies. For example, a significant number of near crashes involve a second vehicle which makes a maneuver that compromises the motorcyclist’s path. However, these events are likely overrepresented compared to those reported for single vehicle events. There is undoubtedly some degree of self-serving bias in this difference. In addition, whereas crash causation studies have indicated that as many as 30% of crashes have a primary cause factor related to rider error, our self-report descriptions contained less than 10% that specifically mentioned an indication of error.

The rider response most often described by participants was braking, followed by a swerve. Braking as the most frequent attempted countermeasure is consistent with results identified through a crash causation methodology. The swerve, since it is a crash avoidance maneuver, is not identified generally through crash causation methods. This maneuver is described 50% less often.

Limitations

Any analysis of written descriptions derived from a self-report survey of study participants will be limited by the amount of detail each participants provide in their description. The average event description was only a few lines in length. This limitation of detail may have caused the coding to involve more inferences than desired. Still, there was enough detail to allow the interrater reliability analysis to attain the minimum criterion.

For this preliminary analysis, each description was treated as an independent example. However, this treatment likely resulted in some error due to the fact that individual participants may have described the same type of safety critical event over more than one visit to the research site. If this is the case, one or more near crash types may be overrepresented in the sample due to an individual pattern of behavior rather than an overall pattern of behavior for this sample of participants. Next steps for this data set will include matching descriptions for each participant so that unique individual patterns can be identified separately, thus, preventing one individual's pattern from having greater impact than it reasonably or statistically should.

Future

The near miss data will be matched with other demographic, riding experience, violation and crash experienced utilized in the full data set for the Discovery Project. In this way, comparison can be made between the treatment condition (RETS) and the control (BRC-only) groups. The results of this analysis have provided an initial look at what types of situations that arise for motorcyclists are described by them as "near misses" and what their self-reported responses are.

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