Comparison of the traffic circumstances based on the analysis of traffic accident statistics in Germany, in the United States and in Japan

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Abstract - In order to enable foreseeing or comparing the benefit of safety systems or driver assistance systems in Germany, in the United States and in Japan, the traffic accident databases in those three countries are examined. The variables used are culpable party, collision partner, accident type, and injury level and the method to re-classify the databases for comparison are proposed. The result indicates that single passenger car fatality is the most frequent in Germany and in the United States, while passenger car vs. pedestrian is the most frequent fatality scenario in Japan. When the casualty by fatality ratio is focused, the greatest difference is observed in rear-end collisions. The ratio of slight injuries in Japan yields about eighteen times as many as those in Germany, and about eight times as many as those in the United States.

INTRODUCTION

To expand the realm of safety systems or driver assistance systems to a new area, it is important to understand the traffic accident facts there. It is certain that almost all countries have statistics for traffic accidents, but at the same time, most of them are insufficient to investigate how the accident occurred. From the standpoint of active safety or primary safety application, the countries that have available data sources equipped with rich information are Germany, the United States and Japan. But it is not easy to compare them because definitions and classifications related to accidents differ by databases. This paper analyses classifications and definitions, and proposes how to re-classify the databases for comparison.

CATEGORIZATION BETWEEN DATABASES

Data sources

The analysed data sources in Germany are GIDAS (German In-Depth Accident Study) and the traffic accident statistics provided from DESTATIS (Statistisches Bundesamt Deutschland). Traffic accidents have been investigated in detail in the two research areas Dresden and Hanover and recorded about 2,000 cases every year which form GIDAS database. GIDAS has about 3,000 variables in total to describe accidents, vehicles, drivers and persons involved in the accidents. Though it does not cover whole Germany, the statistics are representative for the German traffic accident scenario due to the facts that the research areas represent the average German topography very well and that the accidents are investigated according to a statistical sampling plan throughout the year. The final step to make it statistically representative for Germany is a weighting per case to adjust GIDAS data to the same accident distribution as in whole Germany. The cases from 2003 through 2007 were available for the study. The weight allocated to each accident was used and projected to the nation-wide statistics in 2007 available from DESTATIS.

Those in the United States are FARS (Fatality Analysis Reporting System) and NASS-GES (National Automotive Sampling System - General Estimates Systems). FARS covers nation-wide fatality-related statistics while NASS-GES is a sample of motor vehicle accidents that gather about 55,000 cases every year including from fatality-involved through no-injury-involved accidents more than toed away. Both have about 250 variables to describe accidents. The weight is allocated to each NASS-GES accident which makes it possible to know nation-wide statistics. The year 2008 data were used for the study.

That in Japan is provided from ITARDA (Institute for Traffic Accident Research and Data Analysis). The data source covers all casualty-involved accidents. The accidents are described about 70 variables in total. The year 2008 data is compiled by ITARDA and used for the study.

Table 1. Road user categorization

Data source	GIDAS (Germany)	NASS-GES, FARS (United States)	ITARDA's (Japan)
Name of the variable	FZGKLASS (Fahrzeugklasse ; vehicle category) UART * (Unfallart ; character of accident)	IMPUTED BODY TYPE (NASS-GES), BODY TYPE (FARS) IMP FIRST HARMFUL EVENT** (NASS-GES), FIRST HARMFUL EVENT** (FARS)	Toujisha-shubetsu (Kind of party)
Passenger car	Subcompact class Lower midsize class ... Upper class Luxury class etc.	Automobiles Automobile Derivatives Utility Vehicles Van-Based Light Trucks etc.	Large size passenger car Ordinary passenger car Light passenger car (<660cc) Light truck (<660cc) etc.
Truck	Truck Delivery truck etc.	Medium Trucks Heavy Trucks etc.	Ordinary truck Large-sized truck etc.
Bus	Bus Tram etc.	Buses etc.	Bus Minibus etc.
Motorcycle	Motorized 2 wheel vehicle Motorized bicycle etc.	Motorcycles Mopeds etc.	2-wheeled vehicle Mopeds etc.
Pedal cyclist	Bicycle etc.	Pedal cycle or Pedal cyclist **	Bicycle
Pedestrian	Vehicle-pedestrian *	Pedestrian **	Pedestrian
Other vehicles	Train etc.	Snowmobile, Farm equipment etc.	Special purpose vehicle etc.

Road user

These databases have detailed variables to identify involved vehicles. One can investigate by vehicle model or by vehicle manufacturer. The precise variable next to it is the type of vehicles with different amounts of categories. GIDAS has about 40 of vehicle categories[1], FARS and NASS-GES has about 60[2],[3] and ITARDA's has about 20[4]. To get an easier outlook, they are grouped into passenger car, truck, bus, motorcycle, pedal-cyclist pedestrian and others. The result is shown in Table 1.

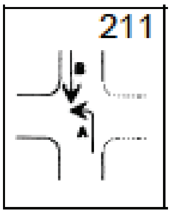
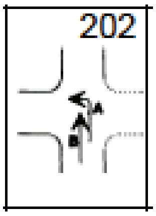
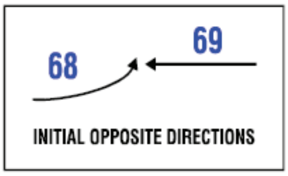
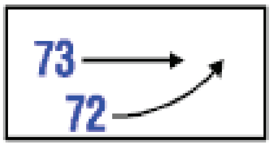
Accident type

Distinguishing multi-vehicle accident

Vehicle-to-vehicle type of accidents are defined as rear-end, head-on, crossing, collision during left turn, collision during right turn and so on in ITARDA's data. The classifications were applied to those from GIDAS and the NASS-GES.

As for GIDAS, "UART (Unfallart ; character of accident)" looks similar but does not match to the categorization in Japan. The diagrams in "UTYP (Unfalltyp; type of accident)" which is coded according to the catalogue of the HUK from 1977, are used for distinction.
As for NASS-GES and FARS, "MANNER OF COLLISION" looks similar, but in the strict sense of the variable, it indicates not a vehicle manoeuvre before collision but impact direction. The diagrams defined in "ACCIDENT TYPE" in NASS-GES are used for distinction while FARS does not provide diagrams so far. An example for collision during left turn is shown in Table 2.

Table.2 Definition of “Turning Left”

Data source	GIDAS (Germany)	NASS-GES (United States)	ITARDA's (Japan)
Name of the variable	UTYP (Unfalltyp ; type of accident)	ACCIDENT TYPES	Jiko-Ruikei (Type of accident)
Collision during turning left	211 - TO - left turning vehicle and oncoming traffic in lane, straight  281 - Turning - vehicle turning left with green arrow light and oncoming traffic ahead  202 - TO - following vehicle besides left turning vehicle  etc.	68 Turn Across Path: Initial Opposite Directions (Left/Right) & 69 Turn Across Path: Initial Opposite Directions (Going Straight)  72 Turn Across Path: Initial Same Directions (Turning Left) & 73 Turn Across Path: Initial Same Directions (Going Straight) 	During right turn (As vehicles are driven on the left-hand side of the road in Japan) [No diagram]

There is another difference for the United States. Vehicle to pedal cyclist accidents are not covered under the variable “Vehicle to Vehicle” accident but in “Forward Impact: Pedestrian/Animal” in “ACCIDENT TYPE”.

Distinguishing single-vehicle accident

Various collision objects and non-collision events are defined in GIDAS, NASS-GES and FARS, while there are less than 10 in ITARDA’s. Compared to other databases, some are not defined because of the low collision occurrence in the country. The proposed re-classification for all 3 databases is shown in Table 3.

Distinguishing culpable party and collision partner

GIDAS distinguish them with the name of “First road user” and “Second road user” and ITARDA’s distinguish them with the name of “Primary party” and “Secondary party” while the FARS and NASS-GES don’t. How the distinction for NASS-GES collision during left turn is achieved is shown in the Figure 1 as an example.

Table.3 Collision partner categorization in single vehicle accident

Data source	GIDAS (Germany)	NASS-GES, FARS (United States)	ITARDA's (Japan)
Name of the variable	KONTRAH (Kollisionskontrahent; Collision Partner)	IMP FIRST HARMFUL EVENT (NASS-GES), FIRST HARMFUL EVENT (FARS)	Jiko-Ruikei (Type of accident)
Post, pole or support	Pillar, Pole of traffic sign, Sign bridge, Traffic light, Road lantern, Power pole, Traffic guidance object etc.	Post, pole or support (sign post, utility post) etc.	Light pole, Road sign etc.
Tree	Tree, Coppice etc.	Shrubbery, Bush etc.	-
Guardrail	Guard rail , Guard rail pillar etc.	Guardrail	Guard fence etc.
Concrete traffic barrier	-	Concrete traffic barrier	-
Fence, wall or building	Wall, Fence, House wall	Building, Fence, Wall	House Wall
Bridge structure	Bridge balustrade, pier, plane	Bridge structure	Bridge and pier
Other fixed object	Switch cabinet etc.	Crash cushion, Fire hydrant	Other structures
Parking vehicle	Parking vehicle	Parked motor vehicle	Parked vehicle
Animal	Animal	Animal	-
Other object not fixed	Object on road	Thrown or falling object etc.	-
Rollover/overturn	Rollover	Rollover/overturn	Turning over
Road surface or embankment	Road surface etc.	Embankment	-
Curb	Curbstone	Curb	Central reservation
Culvert or ditch	Road side ditch	Culvert or ditch	-
Drive off road	-	-	Running off the road
Other	Sidewalk, Water etc.	Fire/explosion, Immersion etc.	Others

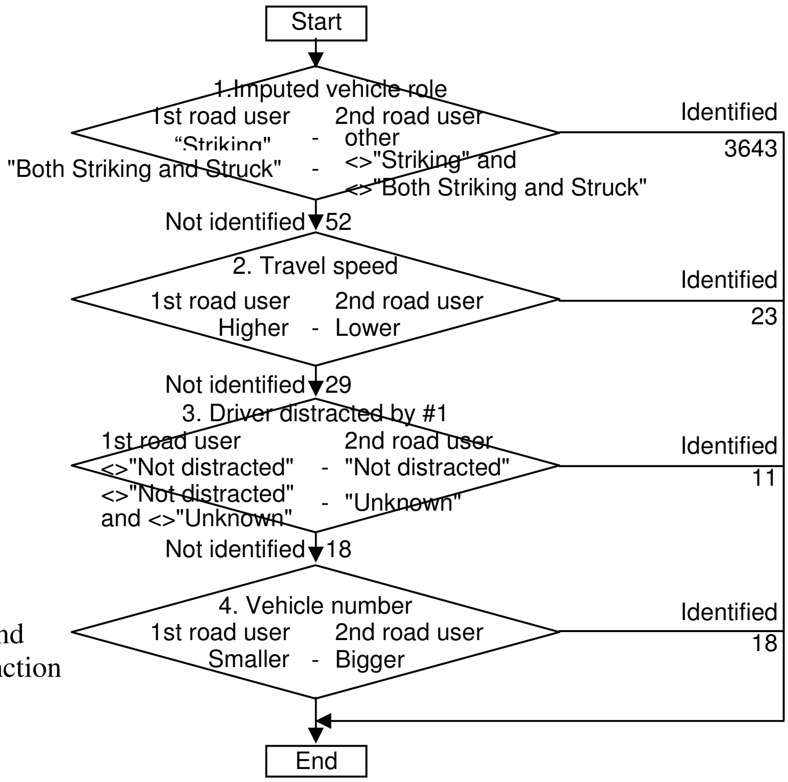


Figure.1 Culpable party and collision partner distinction

Definition of fatality, serious injury and slight injury

GIDAS and ITARDA's have this variable, but with different criteria. NASS-GES has a KABCO (K:Fatal, A:Incapacitating injury, B:Nonincapacitating injury, C:Possible injury, O:No injury) scale, but not directly related to serious injury and slight injury. The comparison is shown in Table 4.
A NHTSA report provides a matrix to transfer KABCO scale to MAIS scale (MAIS6: Fatal, MAIS5: Critial, MAIS4: Severe, MAIS3: Serious, MAIS2: Moderate and MAIS1: Minor)[5]. In this study, NASS-GES data was transferred and regarded MAIS 1 as slightly injured person, MAIS 2 to 5 as seriously injured person and MAIS 6 as fatality.

Fatality within 24 hours (here after, 24-hour fatality) has kept on recording in Japan, but fatalities within n days (n=2,3…, 30 : here after for example, 30-day fatality) have also been and are still kept recorded since 1993. This enables to compare the difference between 24-hour fatality and 30-day fatality easily.

Figure 2 shows the breakdown of the fatality by human damage area[6]]. 2-to-30-day fatality occupies about 14% of 30-day fatality. It can be seen that fatality by head damage increases from 2 to 30 days while thorax and abdomen damages decrease. Whole body damage fatality is limited within 24 hours.

When the increase from 24-hour fatality to 30-day fatality by the road user combination is compared, as shown in Figure 3(a), the combinations of passenger car vs. motorcycle or pedal cyclist are higher than average of 14%. The combinations among motorcycle, pedal cyclist and pedestrian are also higher than average. The reasons are head damage occurrence is higher among them. On the contrary, truck-involved fatality is lower than passenger-car-involved fatality. This is because trucks have a strong tendency to bring instantaneous deaths to others than other road users do.

Table 4. Injury level definition

	Germany	United States	Japan
Fatality	Any person killed immediately or dying within 30 days as a result of an accident.	K – Killed : The death of a person within 30 days of the crash	Died within 24 hours as a result of accident / Died within a month (30 days) as a result of accident.
Person seriously injured	Any person injured in an accident who is immediately hospitalized (for at least 24 hours).	A – incapacitating injury B – non-incapacitating injury	A person who needs medical treatment for a month (30 days) or more.
Person slightly injured	Any person injured who is neither killed nor seriously injured in an accident.	C – possible injury	A person who needs medical treatment for less than a month.

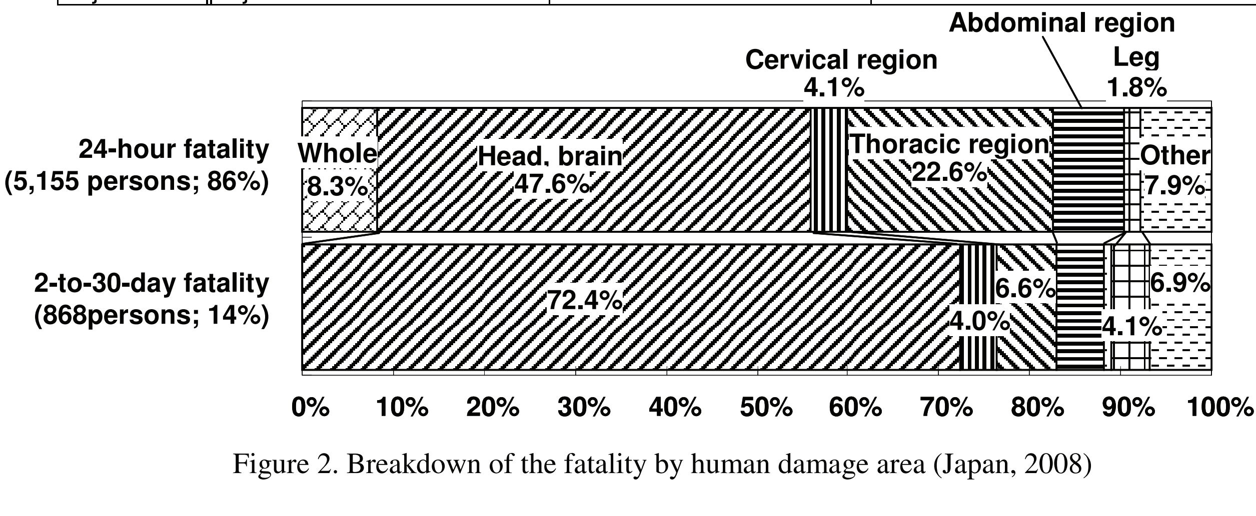
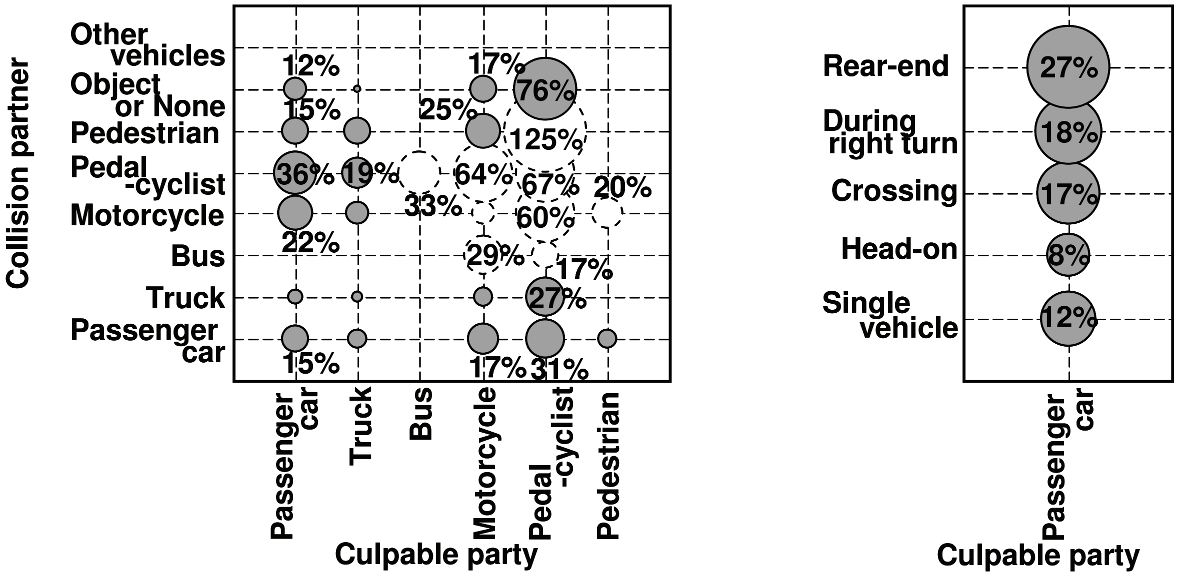


Figure 2. Breakdown of the fatality by human damage area (Japan, 2008)

The increase from 24-hour fatality to 30-day fatality by the accident type, limiting passenger car as the road user, is compared. It is shown in Figure 3(b). The result indicates that head-on and single vehicle accidents yield lower increase while rear-end accidents yields higher increase. The difference indicates that head-on and single vehicle accidents tend to yield instantaneous deaths while rear-end accidents do not.

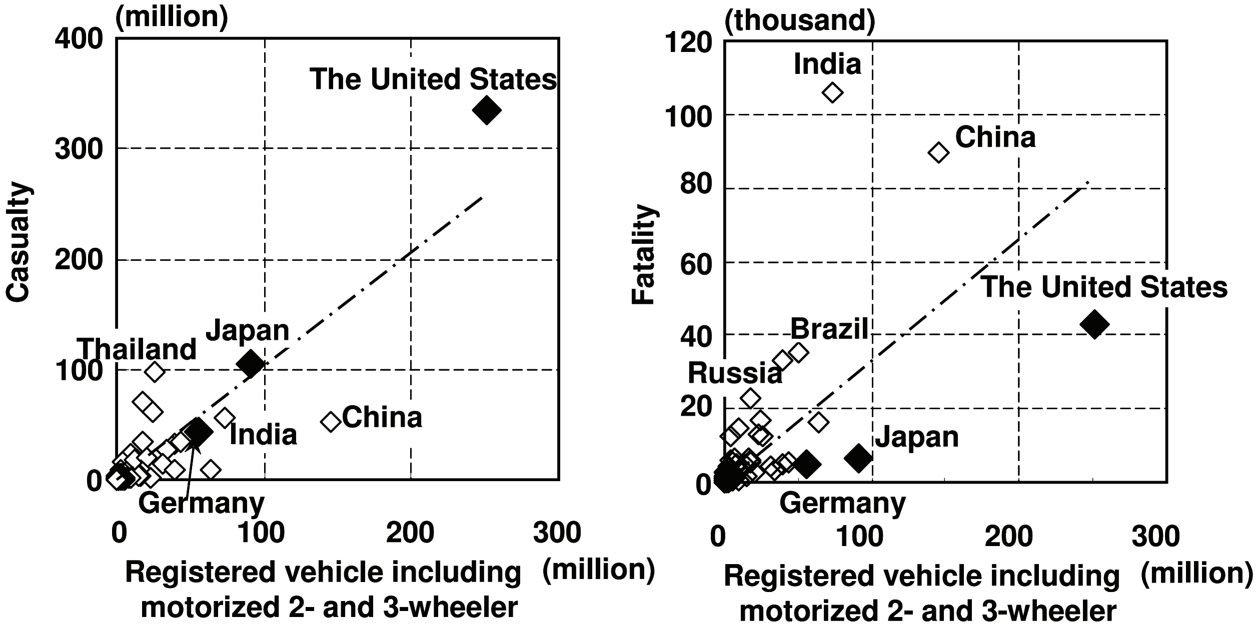
Figure 4 shows where the 3 countries are positioned in the traffic accident statistics in the world[7]. Figure 4(a) indicates the relation between registered vehicle and fatality and Figure 4(b) indicates the relation between registered vehicle and casualty. The graphs indicate that the three countries are in the middle range in the world as for casualty, while they are in the low range as for fatality.

From the next chapter, fatality means 30-day fatality.



(a) By the road user combination (b) By the accident type

Figure 3. The increase from 24-hour fatality to 30-day fatality (Japan, 2008)



(a) Casualty ratio (b) Fatality ratio

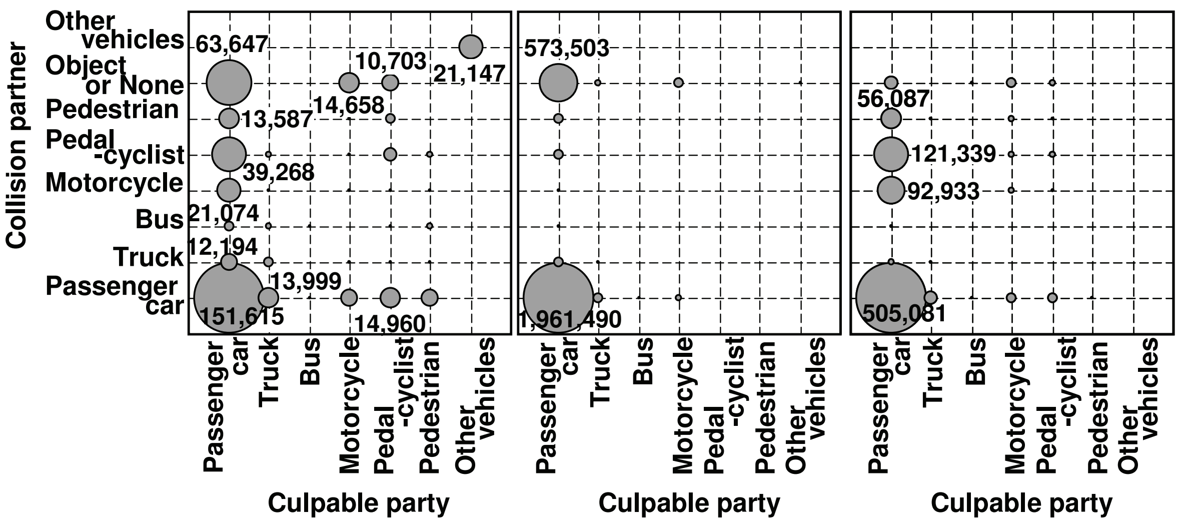
Figure 4. Country profiles in the world

COMPARISON OF TRAFFIC ACCIDENT STATISTICS

Combination of culpable party and collision partner

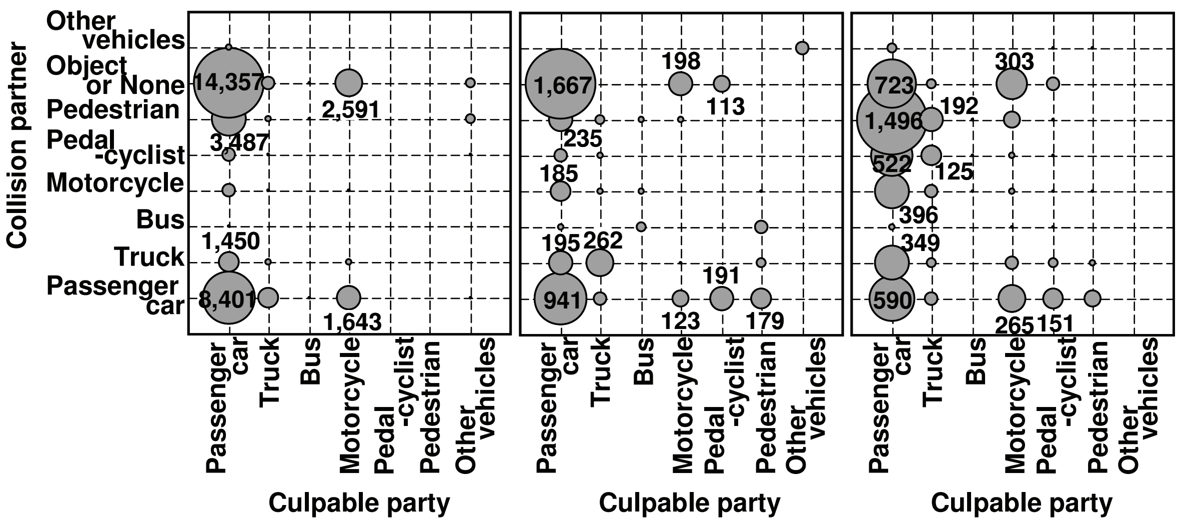
The categorizations defined above were applied to the data sources. Figure 5 indicates that injury in passenger car vs. passenger car accidents is the most frequent in all three countries. However, fatality frequency is different for each country. Figure 6 indicates that passenger car fatality without a collision partner, (hereafter defined as single vehicle accident) is the most frequent in Germany and in the United States, while passenger car vs. pedestrian is the most frequent fatality scenario in Japan. Passenger car vs. motorcycle and pedal-cyclist yield many casualties and fatalities in Japan compared to the United States, while they yield moderate frequency in Germany.

Though the most frequent scenario is different for each country, it is clear that passenger-car-caused casualty and fatality are commonly frequent. In the following, passenger-car-caused accidents are analyzed more in detail.



(a) Germany (b) The United States (C) Japan

Figure 5. Casualty by the combination of culpable party and collision partner

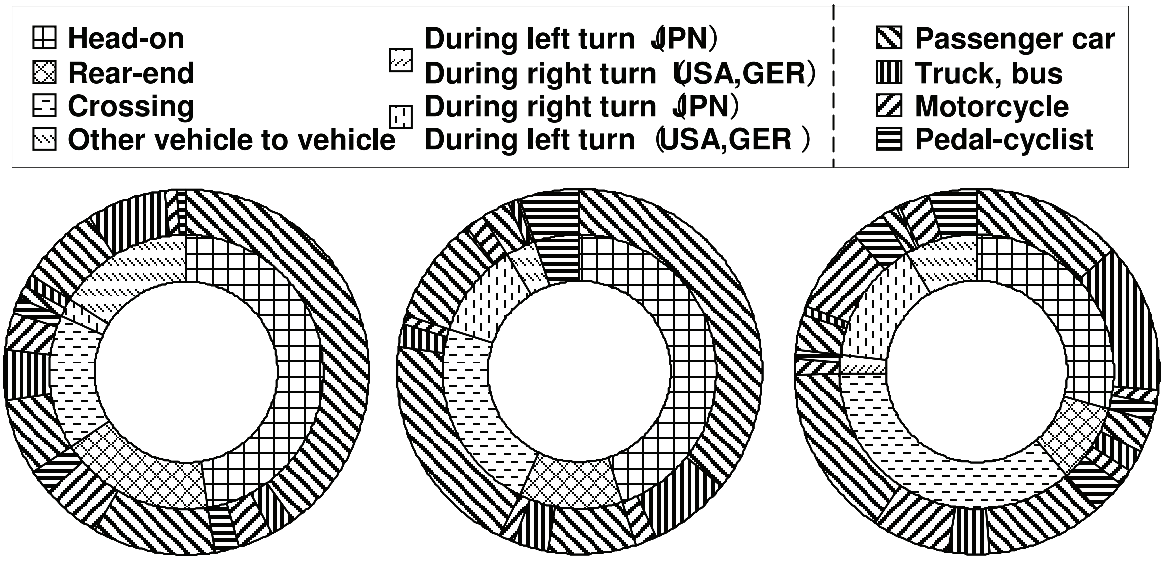


(a) Germany (b) The United States (C) Japan

Figure 6. Fatality by the combination of culpable party and collision partner

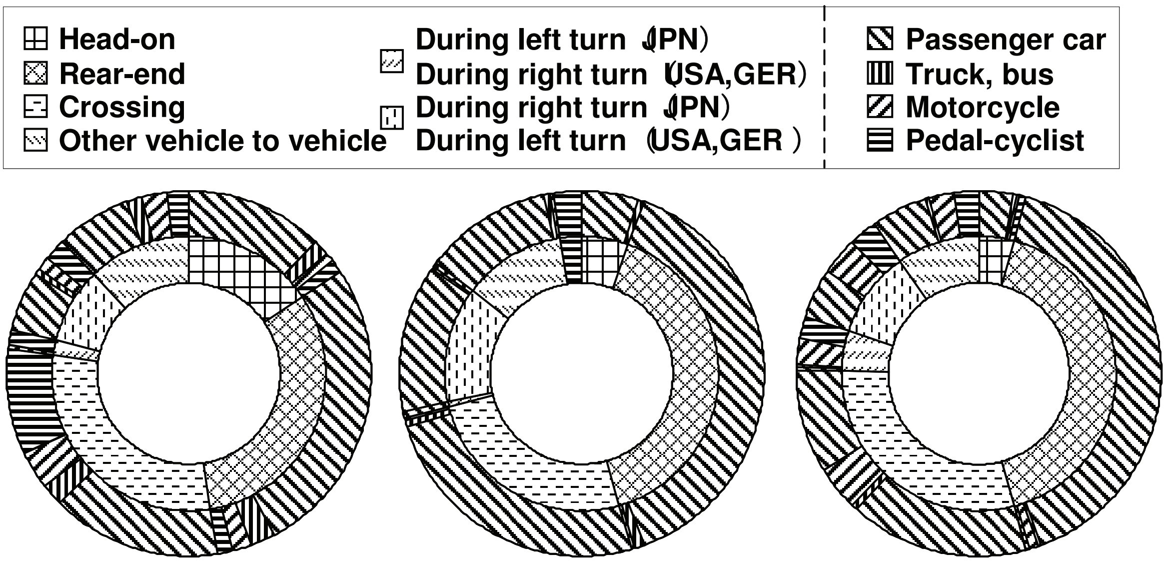
Passenger-car-caused accidents

Casualties caused by passenger car accidents are examined by type of accident and collision partner. It is shown in Figure 7. It can be seen that rear end collision and crossing collision are the most common major types in all three countries. It is observed that various collision partners exist in crossing collisions in Germany and in Japan. As shown in Figure 8, difference is more prominent when fatality-involved accidents are examined. Passenger car is the most common collision partner for passenger car in the United States but various collision partners are observed in Japan. It can be imagined that a greater variety of vehicles are in traffic in Japan, as compared to the other countries. German statistics fall between the United States and Japan for this scenario.



(a) Germany (b) The United States (c) Japan

Figure 7. Passenger-car-caused casualty by type of accident and by collision partner

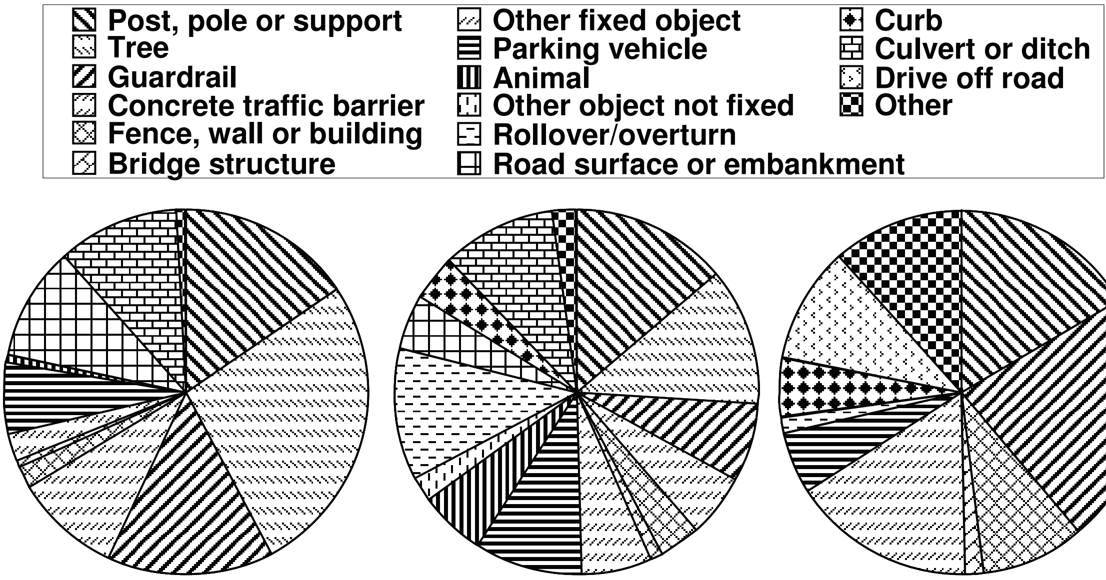


(a) Germany (b) The United States (c) Japan

Figure 8. Passenger-car-caused fatality by type of accident and by collision partner

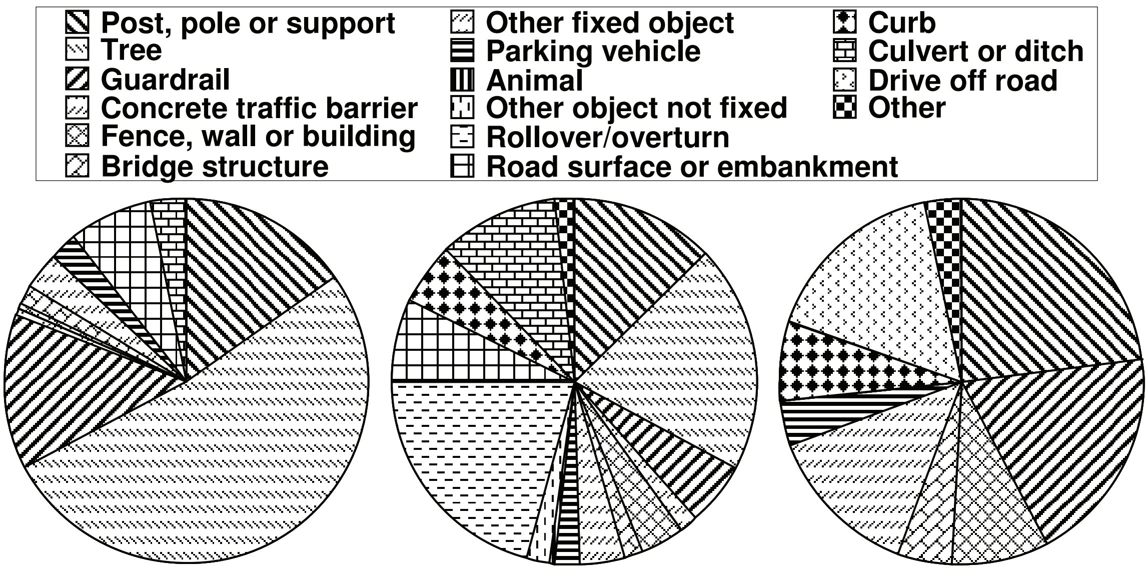
Single Passenger car accidents

The collision partners in casualty-involved accidents in single passenger car accidents are shown in Figure 9 and in fatality-involved accidents are shown in Figure 10. The charts indicate what harm exists beside roads. The chart listing fatalities makes the difference more prominent. In Germany, a roadside tree is the most frequent collision partner, followed by guard rail, pillar and road surface, which is including paved road, sidewalk, bicycle lane downward slope etc. In the United States, The most frequent collision object is a tree in woods, followed by rollover/overturn, pole or support, and culvert or ditch. In Japan, Post, pole or support and guard rail are the most frequent target, followed by other roadside structure and drive off road.



(a) Germany (b) The United States (c) Japan

Figure 9. Casualty in single passenger car accidents



(a) Germany (b) The United States (c) Japan

Figure 10. Fatality in single passenger car accidents

Casualty by fatality

As shown in Figure 11, the casualty by fatality ratio is compared by accident type, limiting the combination as passenger car vs. passenger car or single passenger car, making fatality count as control (=1) in the three countries. As easily imagined by Table 4, it is not adequate simply to compare the casualty/fatality ratio between countries. It is considered strongly depend on the extent of maturity of traffic society and/or the insurance system. However, single passenger car accident yields similar casualty outcome distributions in the three countries. For head-on collisions and crossing collisions in Japan, the ratio of slight injuries is about three times greater as that of the United States, while the German ratio falls in between. The casualty distribution during a left turn (which is the equivalent traffic scenario to a right turn in Japan) shows a different tendency. The ratio of slight injuries in Germany yields about three times as many as those in the United States, with Japan in between. The greatest country to country difference in casualty distribution is in rear-end collisions. The ratio of slight injuries in Japan yields about eighteen times as many as those in Germany, and about eight times as many as those in the United States.

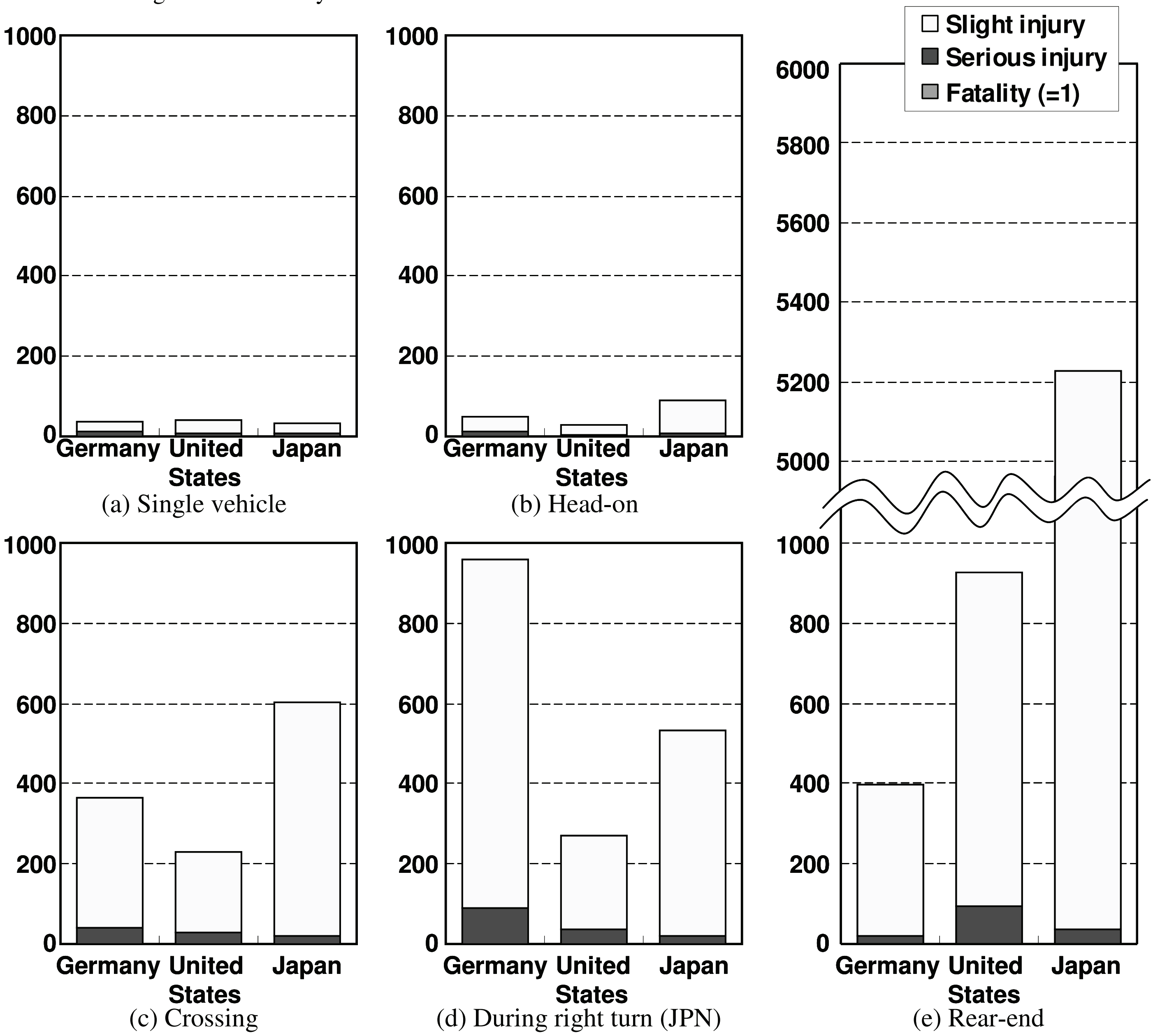


Figure 11. Ratio of casualty by fatality

DISCUSSIONS

The comparison of accident data between the three countries shows points in common and points of difference. Some of these specificities have been suggested before and could now be statistically proven. Through the process, the variables essential to investigate the benefit of active safety or primary safety systems are examined, but a couple of assumptions or interpretations were made that could influence the result. In particular, there might be over- or under-reporting of lower severity accidents. This could be based on the type of injury and the known limitation of comparing the numbers between different countries (like in case of WHIPLASH). It could also be influenced by the sampling method of each both, the police and also the in-depth database. The assumptions or interpretations applied to the databases are listed below with proposal.

Accident type is the most important variable for investigating the benefit of active safety or primary safety systems. Not all accident inspectors are accustomed to the description. Some confuse head-on collision and frontal collision, crossing collision and side collision etc. In order to get proper distinction, traffic accident researcher should clarify the difference. Germany and the United States fortunately have the adequate variable and provide it by diagrams as shown in Table 2 and the United States further more allocate codes for each vehicle involved in the accidents. The idea should be applied to other countries.

Germany and the United States carry many collision partner definitions in single vehicle accident. It is useful considering sensor detection ability in safety systems, but will be better having middle layer categorization like proposed in Table 3 for easier outlook and comparison between countries.

Pedestrian's and pedal cyclist's positions and moving directions are recorded in Germany and in Japan. Those manoeuvres are also important considering safety system ability and are desirable to be recorded in other countries.

The report utilized "VEHICLE ROLE" in FARS and NASS-GES for the distinction, interpreting a "strike" vehicle as culpable party and a "struck" vehicle as collision partner for convenience. It is incorrect, for in the databases, striking is used if a vehicle in motion contacts another with its leading end and/or side and struck is used if a vehicle is moving forward contacts another with other than its front[8]. Distinguishing culpable party and collision partner in multi-vehicle accident is important, for driver assistance system is beneficial mainly to culpable party. The distinction should be equipped with traffic accident databases.

Vehicle speed is one of the most important variables, but the report did not address it. It is included for almost 100% in the data in Japan, about 90% in the data in Germany while about 40% in the data in the United States. Even if it is recorded, its reliability is doubtful especially in fatal accidents, for it is fundamentally based on drivers' statement after accidents. Recently, though limited cases so far, EDR (event data recorder) data which records pre-crash and post-crash vehicle data in a crash becomes available in the United States on NHTSA (National Highway Traffic Safety Administration)'s website[9]. As EDR is expected to be equipped with almost all passenger cars in near future, it is desired to be accumulated in traffic accident databases.

CONCLUSIONS

In order to enable foreseeing or comparing the benefit of safety systems or driver assistance systems in Germany, in the United States and in Japan, the traffic accident databases in those three countries are examined. The variables used are culpable party, collision partner, accident type, and injury level and the method for the re-classification for comparison are proposed.

The result shows that when analyzed by the combination of culpable party and collision partner, injury in passenger car vs. passenger car accidents is the most frequent in all three countries. However, single passenger car fatality is the most frequent in Germany and in the United States, while passenger car vs. pedestrian is the most frequent fatality scenario in Japan.

When passenger-car-caused accidents are examined by type of accident and collision partner, rear end collision and crossing collision are the most common major types in all three countries. It is observed that various collision partners exist in crossing collisions in Germany and in Japan. Passenger car is the most common collision partner for passenger car in the United States but various collision partners are observed in Japan. German statistics fall between the United States and Japan for this scenario.

When single passenger car accidents are examined, a roadside tree is the most frequent collision partner in Germany. In the United States, the most frequent collision object is a tree in wood and another scenario is rollover/overturn. In Japan, post, pole or support and guard rail are the most frequent target.

When the casualty by fatality ratio is compared by accident type, the greatest country to country difference in casualty distribution is in rear-end collisions. The ratio of slight injuries in Japan yields about eighteen times as many as those in Germany, and about eight times as many as those in the United States.

The method to compare the traffic accident statistics between three countries that allow accident analysis including accident scenario is considered successfully and will help in the future to analyse the achievable merit of active safety systems in each country. However, it is unavoidable to make assumptions and caution needs to be kept to not let them bias future finding.

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