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Exploring Rear-End Roadway Crashes from the Driver's Perspective

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16. Abstract

This pilot study examined rear-end crashes from the driver's perspective to identify self-reported reasons and causes of such crashes, to identify commonalities in the self-reported causes and locations and circumstances of these crashes, and to explore the merit of using this approach to develop countermeasures to the rear-end crash.

Focus groups and telephone interviews were used to obtain descriptions and perceptions of rear-end crashes from a sample of 26 subjects who had recently experienced such crashes as drivers of striking vehicles. Drivers tended to attribute the crash to different causes depending on how they were questioned about the crash. Actions of the other driver was the dominant contributing factor reported by most subjects when asked directly for causes of their crash. This was followed by personal inattention or distraction. Different responses, related to cognitive issues, were obtained when subjects were asked to explain what happened leading up to and during the crash. The majority of the reasons obtained by the second approach could be accounted for by subjects' problems with divided attention and incorrect assumptions about traffic movement. Classifying the crashes by cognitive issues provided an approach that could be applied to the development of concepts for countermeasures to rear-end crashes.

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INTRODUCTION

Rear-end crashes are a very common type of vehicle crash and occur when a following vehicle strikes the rear of another vehicle that is in the same traffic lane and headed in the same direction. From the early days of motorized transportation, various countermeasures have been sought to reduce the frequency of this type of crash. Most of the countermeasures developed in response to this need are either part of the vehicle itself or part of the roadway system. The intent of most current in-vehicle systems is to increase the conspicuity of the lead vehicle or to inform the following vehicle that the lead vehicle is decelerating. Among such countermeasures are rear lights, reflective license plates, rear fog lights, brake lights, centrally high mounted third brake lights, hazard signals, and flashing brake lights. Signs such as the stop-ahead sign, the flashing signal-ahead sign, construction-expect-delay sign, and changeable message signs that warn motorists of congestion ahead act as countermeasures to rear-end crashes by informing drivers that there may be stopped vehicles ahead.

Although these countermeasures have done much to reduce the frequency of rear-end crashes, these crashes still occur, and new ways to address the problem are constantly being sought. Intelligent transportation system (ITS) technology has introduced new countermeasures such as headway-monitoring systems, collision warning devices, and sleep-monitoring/warning systems that may have a positive effect on reducing rear-end crashes. ITS has also introduced the possibility of electronic communication between the vehicle and the roadway. Systems that monitor traffic flow on roadways and inform drivers of the traffic status via changeable message signs or in-vehicle receivers are now being tested. Automated highway systems that move platoons of vehicles at high speeds and very short headways over long distances and various collision-avoidance systems are in the research-and-development stages, and it is very likely that such systems will eventually contribute to reducing the frequency of rear-end crashes.

When considering the problem of reducing the frequency of a certain type of crash, a variety of solutions (i.e., countermeasures) may be generated by looking at the problem in a variety of ways. Some ideas come from examining statistical crash data to determine the prevalent types of crashes and patterns of occurrence. Other concepts are formed by examining individual crashes in great detail. Still other ideas come from solutions looking for a problem; that is, they result from the desire to apply a particular type of technology. Another approach to identify countermeasures for reducing crash frequency, suggested by staff at Honda R&D North America, is to look at the crash from the perspective of the driver. Honda staff wanted to know whether or not this approach could yield innovative solutions to the problem of motor vehicle crashes. Accordingly, they asked us to explore a specific crash type, the rear-end crash, from the perspective of the driver and to determine if this approach has merit for developing countermeasure ideas.

Goals and Objectives

The goal of this research was to further understand roadway crashes by exploring the rear-end crash from the driver perspective and to determine if knowledge of the circumstances of the crash as perceived by the driver could offer insight into the characteristics of potential countermeasures for rear-end crashes. The objectives of the study were to:

- Identify self-reported reasons why rear-end crashes occur
- Identify how these driver-reported reasons relate to certain situations and locations
- Identify crash hazard cues drivers recognized or failed to recognize
- Determine whether this approach has merit for developing countermeasure ideas

It is important to note that this was an exploratory (pilot) study. While it may provide some interesting and useful insights, it serves primarily as a test of methods and assumptions so that a full-scale study can be designed and conducted efficiently to obtain statistically valid results.

METHODOLOGY

Approach

A qualitative approach using focus groups was selected for this study. A focus group is a carefully planned discussion, guided by a moderator, among people who have something in common. It is designed to obtain perceptions on a defined topic in a permissive, nonthreatening environment and is conducted several times with similar types of participants. Typically there are 8 to 10 participants in a group. Careful and systematic analysis of the discussion provides the clues and patterns in the perceptions of the subjects. Results of focus groups cannot be generalized to the population from which the subjects were drawn, but can be used to formulate ideas and hypotheses for further quantitative research. As an exploratory tool, focus groups initially seemed well suited for the purposes and pilot nature of this study.

The subjects for this study were drawn from the population in Michigan who had recently experienced a rear-end crash as drivers of the striking vehicle. Because of possible age differences in the perception of the circumstances surrounding a crash, subjects were initially divided into three age categories, 19-to-24, 25-to-64, and 65 or more years of age. These age categories were selected because overall crash involvement by drivers' age follows a distinct pattern, which generally corresponds to these age categories. Two focus group sessions were planned for each age group.

The moderator's guide was developed to include a detailed outline of the topics and questions to be used in the focus group. The guide was designed to elicit information about the crash as perceived by the driver, including subjects' perceptions of the key contributing factors and causes of the crash. Subjects' ideas about what could have helped to prevent their crash and rear-end crashes in general, as well as their acceptance of some potential crash-prevention systems, were sought. The complete moderator's guide can be found in appendix A.

Sampling

The State of Michigan Crash files for 1996 were used to develop the sampling base for the study. At the time of the study, 1996 was the most recent year for which a complete set of crash data was available. The files were filtered to retain the records of the striking vehicle in rear-end crashes that occurred in four southeastern Michigan counties: Livingston, Oakland, Washtenaw, and Wayne. These counties were selected to keep the travel time of potential subjects to the focus group to no more than 1 hour. The records were further filtered to exclude crashes that involved alcohol, animals, and fatalities. Alcohol and animal crashes were excluded at the request of the sponsor. Fatal crashes were excluded because these crashes were likely to have been very traumatic for involved drivers and it would, therefore, be extremely difficult to recruit these drivers for the study. Because the crash-involvement rate for men is higher than for women in all three age groups, it was possible that a random sample drawn for each age group might have few or even no women. To ensure that study subjects included women, men and women in each age category were sampled separately. Table 1 shows the number of potential subjects (sampling base) in each age and sex category.

Table 1. Number of Drivers in Sampling Base

Age Group	Male	Female
19-to-24	4,119	2,736
25-to-64	11,725	7,823
65-and-over	1,055	637

Based upon previous experience recruiting subjects and the nature of the topic, we estimated that a 10 percent success rate in recruiting subjects was likely. Because we wanted a total of about 60 subjects (ten for each category), a random sample of 110 crash records from each age and sex category was drawn from the sampling base for a total of 660 records. Printed copies of the police crash reports (UD-10) for these 660 cases were obtained from State of Michigan microfiche files. Among other information, UD-10 reports contain narrative descriptions of the crash and the names, addresses, and telephone numbers of the people involved.

Subject Recruitment

Letters were sent to all 660 potential subjects describing the study, telling them that they would receive a call in the near future, and inviting them to participate in a focus group. The letters also informed them that they would receive a subject payment of $35. A copy of the recruitment letter is presented in appendix B.

Recruitment began several days after the letters were mailed. An experienced project staff member telephoned potential subjects, explained the study, and invited them to participate in a focus group. If they agreed, he scheduled them for a session. As the recruiting process got under way, it became obvious that a large majority of potential subjects were not interested in participating in focus groups on this topic and that obtaining the desired number of subjects would be difficult. Many potential subjects were irritated that we knew about their crash and several denied being in a crash. Approximately half way through the recruitment process we increased the subject payment to $50 in order to provide additional incentive for participation. This increase in subject payment, however, did not result in an increased participation rate. In all, 30 people agreed to participate in the focus groups.

Focus Groups

Focus groups were held at UMTRI in the last week of July and the first two weeks of August, 1998, and were moderated by a researcher. The sessions were videotaped, audio taped, and a research secretary took detailed notes. Five focus group sessions were held with a total of 16 subjects. There was a total of 10 participants in the two focus groups for drivers 65 years of age or older and a total of 3 participants in the two sessions for the drivers in the 19-to-24-year-old age group. Only one focus group, with 3 participants, was held with drivers 25 to 64 years of age. Thus, a total of only 16 of the 30 people who agreed to participate actually showed up for the focus groups.

Before each session, subjects signed informed-consent forms and filled out a demographic questionnaire. They received payment for participation at the end of the session. A copy of the informed consent form is in appendix B. The demographic questionnaire can be found in appendix C.

Telephone Interviews

Recruitment calls to 660 potential subjects yielded only 16 actual participants. However, an additional 14 people had agreed to participate but did not come to the sessions. We, therefore, decided to obtain the crash information from each of these 14 people through a telephone interview using the moderator's guide from the focus groups as the interview instrument. Changing the method of data collection in the middle of this study was justified for two main reasons. First, this was a pilot study where assumptions and methods were being tested. As such, the focus group method was proving untenable and a different method was needed. Second, with one exception, the focus group sessions had a small number of subjects and took on a form more similar to an interview than to a focus group. Because of this we were confident that the information collected by each of the two methods was generally compatible and could be combined for analyses in a pilot study.

A researcher called each of the 14 people who had failed to show up for their scheduled focus group and asked if he could conduct the interview over the telephone. If the person agreed, he either conducted the interview by following the questions in the moderator's guide or scheduled the interview for a more convenient time. The information covered in the informed consent form was read to the subject, and his/her consent was obtained verbally. The telephone interviews were audio taped with the permission of the subject. Demographic information was also collected. Subject payments were mailed to the subjects who completed the interview. In all, 10 subjects were interviewed over the telephone. The other 4 people refused to be interviewed.

Sample

Subjects

There were 26 subjects in the final sample. Of these 11 were male and 15 were female, 10 were in the 19-to-24-year-old age group, five were in the 25-to-64-year-old age group, and 11 were in the 65-years-of-age-or-older age group. Table 2 shows the distribution of the study subjects by age group and sex.

Table 2. Study Subjects by Age and Sex

Age Group	Male	Female	Total
19-to-24	3	7	10
25-to-64	3	2	5
65-and-over	5	6	11
Total	11	15	26

The overall average household income of the study subjects was $42,000. The average household income for the three age groups was $30,000, $75,000, and $37,000 from the youngest to the oldest age group, respectively. Other demographic characteristics of the sample of subjects can be found in appendix C.

Crashes

The electronic crash-data records for the specific rear-end crashes experienced by the 26 subjects were examined. In all 26 crashes, the vehicle was traveling straight ahead and the worst point of impact was the front-center of the car, confirming that the crashes were indeed rear-end crashes and that the subject was the driver of the striking vehicle. Ten of the crashes occurred on two-lane roads and the rest were on multilane roads or freeways. All but one of the crashes occurred during daylight. Precipitation in the form of rain or snow was present in four of the crashes and the rest occurred in clear or cloudy weather. Most of the vehicles involved were passenger cars. No vehicle defects were noted in any of the crashes. In eight of the crashes the vehicle was in slow and stopped traffic. Moderate damage was noted in 11 cases, light damage in 14 cases, and no damage in one case. In five cases there was an injury in the striking vehicle. Of these, two were minor injuries, three were non-incapacitating injuries, and one was an incapacitating injury. The review of these records showed that these crashes were typical rear-end crashes.

RESULTS

Subject-Reported Crash Situations

The 26 crashes, as described by the subjects, occurred mostly during the day and were equally divided between peak traffic periods with heavy traffic conditions and off-peak periods with light to moderate traffic. Most subjects reported that their crash occurred in good weather and a few mentioned rain or snow. The majority of the crashes occurred on streets and only a few were on freeways. Of the crashes that occurred on streets, more than one-half were reported to have occurred at intersections. In most cases, the subjects said that they were the only person in their vehicle and the vehicles they hit were in most cases occupied only by a driver.

Several subjects reported that their crash occurred in congested stop-and-go traffic, when the vehicle in front of them stopped because vehicles ahead had stopped. Two subjects reported that their crashes occurred when they reached down to pick up an item that fell to the floor in their car. Some subjects described crashes that occurred when a vehicle moved into their lane and stopped for some reason. A few subjects drove their vehicles into the car in front of them because they had incorrectly assumed that the car had started moving. There were also several cases where the subject crashed into a vehicle that was stopped in an unexpected location and was not visible to the subject until it was too late. A summary of the subjects' descriptions of each crash can be found in appendix D.

Self-Reported Contributing Crash Factors

The analysis of drivers' responses to what caused their crash showed that the self-reported reason(s) for the crashes was frequently different depending upon how the subject was asked the question. When questioned directly about their crashes, subjects would report one or more reasons, called *question-based factors* here. However, when asked to explain what happened leading up to and during the crash, many subjects reported different factors than when asked directly. We have labeled these types of contributing factors *explanation-based* factors. For example, when asked directly, one subject stated that the crash was entirely because of road design (question-based). However, when she explained what happened during the crash, she reported that she mistakenly watched the wrong set of traffic signals and accelerated when the wrong signals turned green (explanation-based). On the one hand, road design was the cause and on the other, a personal error was the cause. Because these two ways of reporting perceptions of crash causation yielded different responses, we present them separately.

Question-Based Factors

The subjects were directly asked what factors contributed to the crash and to indicate the relative contribution of each factor. A summary of each subject's response can be found in appendix D. Table 3 shows the overall allocation of contributing factors as reported by the subjects. Actions of the other driver was the dominant contributing factor, according to the subjects. The drivers described these actions as the other car stopped unexpectedly, the other car did not move when it should have, and the other car did "strange things." The next most frequent set of responses to this question included personal inattention or distraction. We grouped these into one factor, which we called personal error. Other factors reported by the subjects as contributing to their crashes were road design, environment, and vehicle problems.

Table 3. Self-Reported Main Factors Contributing to the Rear-End Crash (n = 26)				
Road Design	**Environment**	**Actions of Other Driver**	**Vehicle Problems**	**Personal Error (inattention, distraction)**
7%	9%	49%	4%	31%

The following set of tables shows the number and distribution of the self-reported contributing factors for various groupings of subjects. It is important to remember that this is an exploratory study; the number of subjects is small; and the results cannot be applied to the population of drivers. These tables simply provide a convenient way of looking at the information obtained from these study subjects. They also provide a starting point for formulating hypotheses and developing data-analysis plans for any larger scale study that may follow. Furthermore, examining the information this way may offer insights into ways by which these crashes could have been prevented.

Table 4 shows the self-reported contributing factors for the crash by the maneuver of the lead vehicle as described by the subjects. In the majority of cases, subjects stated that the lead car either stopped because of actions of cars further ahead or the lead car was standing at an intersection. For cases where the lead car stopped because vehicles further ahead stopped, actions of the other driver was the factor most likely to be reported by the subjects. For cases where the lead car was standing at the intersection, the subjects were more likely to cite a personal error. There were two other less common maneuvers of the lead vehicle reported by the subjects: The lead car was standing in a lane of travel and the lead car pulled into the subject's lane and stopped. In these cases, the subjects were most likely to attribute the crash to the actions of the other driver.

Table 4. Self-Reported Contributing Factors by Reported Maneuver of Lead Car					
Maneuver of Lead Vehicle (n)	**Road Design**	**Environ-ment**	**Actions of Other Driver**	**Vehicle Problems**	**Personal Error**
Stopped because cars ahead stopped (8)	13%	16%	50%	0%	21%
Standing at intersection (10)	3%	8%	29%	10%	50%
Standing in travel lane (3)	17%	5%	45%	0%	33%
Pulled into lane and stopped (3)	0%	0%	100%	0%	0%
Other (2)	0%	0%	75%	0%	25%

Table 5 shows the distribution of the self-reported contributing factors by sex. The data show that, in this group of subjects, men were more likely than women to attribute crash to the actions of the other driver. Women showed greater variability than men in their self-reported reasons for their crash.

Table 5. Self-Reported Contributing Factors for the Rear-End Crash by Sex					
Sex (n)	**Road Design**	**Environ-ment**	**Actions of Other Driver**	**Vehicle Problems**	**Personal Error**
Male (11)	0%	10%	65%	0%	25%
Female (15)	12%	8%	38%	6%	36%

Table 6 shows the distribution of self-reported contributing factors by age group. The subjects in the oldest and youngest age groups tended to somewhat equally cite both personal errors and the actions of the other driver whereas those in the middle age group tended to attribute the cause of the crash to the actions of the other driver.

Table 6. Self-Reported Contributing Factors for the Rear-End Crash by Age Group					
Age Group (n)	Road Design	Environ-ment	Actions of Other Driver	Vehicle Problems	Personal Error
18-to-24 (10)	8%	23%	37%	0%	32%
25-to-64 (5)	20%	0%	70%	0%	10%
65-and-older (11)	0%	0%	50%	9%	41%

Table 7 shows the distribution of the self-reported contributing factors in the rear-end crash by the location of the crash. For crashes on the street system, either at intersections or on road segments, the study subjects cited the actions of the other driver and personal error about equally. For crashes that occurred on the freeways, however, the majority of subjects indicated that action of the other driver was the cause of the crash.

Table 7. Self-Reported Contributing Factor by Location of Crash					
Location (n)	Road Design	Environ-ment	Actions of Other Driver	Vehicle Problems	Personal Error
Street - Intersection (12)	3%	7%	40%	8%	42%
Street - Non intersection (8)	0%	16%	48%	0%	36%
Freeway (6)	25%	3%	67%	0%	5%

Table 8 shows that among the subjects in this study there was little difference in self-reported contributing factors by the traffic conditions on the road.

Table 8. Self-Reported Contributing Factors by Traffic Condition					
Traffic Condition (n)	**Road Design**	**Environ-ment**	**Actions of Other Driver**	**Vehicle Problems**	**Personal Error**
Heavy traffic/congestion (12)	6%	7%	44%	7%	29%
Light to moderate traffic (14)	8%	11%	54%	0%	26%

Explanation-Based Factors

As mentioned earlier, when subjects explained what happened leading up to and during the crash, they frequently gave different reasons for the cause of the crash than they gave when asked directly. This section considers these explanation-based factors. Because of a problem with part of the recording of one interview, the explanation for one crash was deleted. This subject is not included in the analysis of explanation-based factors contributing to the rear-end crash.

The responses from the explanations suggested that there were *four* main self-reported causes for rear-end crashes in our sample of subjects. Two causes were related to an *incorrect assumption* about traffic movement made by the driver; that is, the driver thought a vehicle in traffic was going to do something that it did not do. We divided these self-reported incorrect assumptions into two types: normative and non-normative. Normative assumptions are those that a driver in a following vehicle makes about the driver's behavior in a lead vehicle that are based on social driving norms. For example, it is normal for a driver in a following vehicle to assume that the lead vehicle will not stop in the middle of a freeway ramp or stop at a signal-controlled intersection if the light is green. Thus, normative assumptions make sense and are necessary for safe driving. If the driver in a lead vehicle breaks a social driving norm, it increases the chance that a following vehicle will hit it. On the other hand, non-normative assumptions about the driver's behavior in the lead vehicle are those that do not coincide with general driving norms. Examples of non-normative assumptions include assuming that the vehicles in a lane are moving because the vehicles in another lane are moving, or assuming that a lead vehicle is moving because the vehicles some distance ahead of the lead vehicle are moving. Thus, when a driver in the following vehicle makes a non-normative assumption about the actions of the lead vehicle, it is likely to be incorrect and chances of a rear-end crash increase.

A third self-reported cause of rear-end crashes was related to an inability of the driver to *divide attention* effectively. According to Bernstein et al. (1991), divided attention is "devoting psychological resources to more than one task or stimulus at a time." For example, in two of the cases studied, items fell to the floor and the drivers were trying to pick them up when the crash occurred. The final self-reported reason, is that the crash was simply *unavoidable*. In these cases, subjects reported that their rear-end crash was unavoidable and resulted from the actions of drivers several vehicles ahead which they could not see, or from other circumstances over which they had no control.

Table 9 shows the distribution of the 25 crashes by the four categories of self-reported causes. The classification of self-reported causes for each crash can be found in appendix D. The majority of the explanation-based causes of the crashes were related to problems with divided attention and incorrect assumptions about the actions of the lead vehicle, all personal error factors.

Table 9. Self-Reported Causes of the Rear-End Crashes (n=25)

Divided Attention	Incorrect Assumption (non-normative)	Incorrect Assumption (normative)	Unavoidable
32%	32%	8%	28%

Looking at the maneuver of the lead vehicle in our sample of rear-end crashes by the self-reported cause of the crash in table 10 suggested that problems with divided attention were associated with crashes that occurred when a lead vehicle stopped because of cars ahead stopping. This analysis also showed that an incorrect non-normative assumption was more likely in cases where the lead car was standing at an intersection. The table also shows that most of the crashes where the lead vehicle pulled into the subject's lane and stopped were explained as unavoidable.

Table 10. Self-Reported Cause of Crash by Maneuver of Lead Vehicle

Maneuver of Lead Vehicle (n)	Divided Attention	Incorrect assumption (non- normative)	Incorrect assumption (normative)	Unavoid-able
Stopped because cars ahead stopped (7)	71%	15%	0%	14%
Standing at intersection (10)	20%	70%	0%	10%
Standing in travel lane (3)	34%	0%	33%	33%
Pulled into lane and stopped (3)	0%	0%	34%	66%
Other (2)	0%	0%	0%	100%

Table 11 shows that there was no consistent difference in the self-reported causes of the rear-end crash in this study between men and women.

Table 11. Self-Reported Causes of Crash by Sex

Sex (n)	Divided Attention	Incorrect assumption (non-normative)	Incorrect assumption (normative)	Unavoid-able
Male (10)	40%	30%	0%	30%
Female (15)	27%	33%	13%	27%

Table 12 shows the distribution of the self-reported causes of the crash by age group. Incorrect non-normative assumptions were more likely among the youngest group of subjects. This result is interesting because this type of error undoubtedly occurs from inexperience, and the youngest age group would have the least driving experience of the age groups studied. The middle-age-group subjects most frequently described their crash as unavoidable. The oldest age group participants tended to report the cause as either divided attention or unavoidable about equally. This result is also interesting because it is known that in older adulthood, divided attention ability begins to decline (see, e.g., Eby, Trombley, Molnar and Shope, 1998).

Table 12. Self-Reported Causes of Crash by Age Group

Age Group (n)	Divided Attention	Incorrect assumption (non-normative)	Incorrect assumption (normative)	Unavoid-able
18-to-24 (10)	30%	50%	10%	10%
25-to-64 (5)	20%	20%	20%	40%
65-and-older (10)	40%	20%	0%	40%

Table 13 shows that among the subjects, incorrect non-normative assumptions were likely to be the self-reported cause of rear-end crashes at street intersections while problems with divided attention were more likely to be associated with crashes on street segments, away from intersections.

Table 13. Self-Reported Cause of Crash by Location of Crash

Location (n)	Divided Attention	Incorrect assumption (non-normative)	Incorrect assumption (normative)	Unavoid-able
Street-intersection (12)	17%	58%	8%	17%
Street non intersection (8)	50%	13%	0%	37%
Freeway (5)	40%	0%	20%	40%

Table 14 shows the self-reported causes of crashes by traffic condition. We found that in heavy traffic, divided attention and non-normative, incorrect assumptions were the most frequently cited causes of the crash. In light traffic, people were more likely to attribute the cause of the crash to all four factors with unavoidable circumstances being the most frequently cited factor.

Table 14. Self-Reported Causes of Crash by Traffic Condition

Traffic Condition (n)	Divided Attention	Incorrect Assumption (non-normative)	Incorrect Assumption (normative)	Unavoid-able
Heavy/traffic congestion (11)	36%	46%	0%	18%
Light to moderate traffic (14)	29%	21%	14%	36%

Cues About Imminent Crash

We asked subjects if they remembered any cues that a crash was about to occur. Cues were defined as anything that let them know that a crash with the lead vehicle was imminent. Subjects either reported that they detected no clues or that there were no clues of an imminent crash. Most reported that the crash happened before they could think about or notice anything.

Perceptions of Countermeasures

Subjects were asked what could have prevented their crash or rear-end crashes in general. Their responses are listed by frequency of response.

- Drivers should pay more attention.
- If I had more time I could have avoided crash.
- Drivers should leave more room between cars.
- Better roadway design would have helped.
- A device to let you know if car ahead is slowing down or not moving would have helped
- Vans and other large vehicles should be moved to a separate lane.

- Better laws and enforcement of laws would help.
- A device that would not let you move if car immediately ahead was not moving would help.
- Reducing the number of cars on the road would help.

Several subjects also brought up the topic of public information and education programs about following too closely and indicated that such programs would not reduce the number of rear-end crashes because most people know the rules about how far behind the car in front they should be, but drive too closely anyway.

We were also interested in the subjects' reactions to some countermeasure system concepts. We described two ITS systems presently under development (an in-vehicle headway-monitoring/warning system and an in-vehicle sleep-monitoring/warning system) as possible ways of reducing the number of rear-end crashes. The headway-monitoring/warning system was described as a system that monitors the distance between a car and the car ahead of it and determines if the distance is safe for the current driving speed. If the distance between the cars is closing too quickly for the speed, the system warns the driver and, in some versions of the system, decelerates the car. The sleep-monitoring/warning system was described as a system that tracks the steering motion of the car. We told the subjects that when a driver starts falling asleep, the steering patterns become erratic. The sleep-monitoring system would sense this and issue some type of warning to arouse the driver. No specific type of warning was described.

Subjects were asked what they thought of each system, if they would be willing to use them, and how much would they be willing to pay for them. The majority of the subjects thought the headway-monitoring/warning system was a good idea, and they would probably use it. Several others expressed concerns that a warning would not be enough, that people would ignore it, that it might help others, but that they do not need it. A few said that it would be a distraction, and they would not use it.

About one-half of the subjects were willing to state how much they would pay for such a headway-monitoring/warning system. The average amount these subjects were willing to pay for this system was approximately $500 and ranged from $25 to $1,000. Several subjects indicated that such a system should be standard equipment on vehicles. Several others said they would like to see the system proven effective before they would put a monetary value on it.

Subjects' responses to the sleep-monitoring system were generally positive. Several subjects reported that they themselves did not need such a system, but it was a good idea for other drivers. Several subjects mentioned that it was a good idea for truck drivers, and some thought it should be standard equipment on trucks. About half of the subjects provided a monetary value for the sleep-monitoring/warning system. The average amount they were willing to pay was about $400, and the values ranged from $25 to $1,200.

DISCUSSION

This pilot study explored rear-end crashes from the perspective of the driver to ascertain whether or not this approach was useful for developing concepts for rear-end-crash countermeasures. Recruiting subjects for the study proved to be difficult, primarily because the crash was a sensitive issue for nearly all potential subjects. Many potential subjects were annoyed that we knew about their crashes. The method of obtaining driver-reported information about the crash through focus groups was not effective. However, the same information was much more easily obtained through individual telephone interviews, suggesting a more promising avenue for this type of research in the future.

The study showed that drivers tended to attribute the causes of their crashes to different factors, depending on how they were asked about contributing factors. Thus, it is important to assess driver perceptions of crashes by both asking people directly about the cause and having them explain the events leading up to and during the crash. The analysis of question-based factors showed that drivers most frequently attributed the cause of their crash to the actions of another driver. Unexpectedly, the second most frequently reported cause was personal error. Environmental conditions, road design, and vehicle problems were mentioned infrequently. Analysis of the explanation-based factors showed that the large majority of self-reported contributing factors were related to cognitive issues, with failure of divided attention and incorrect assumptions about traffic movement accounting for about 70 percent of the reasons mentioned. For the purpose of generating new concepts for countermeasures to reduce the frequency of rear-end crashes, the explanation-based factors were more informative than the question-based factors.

Concepts for Potential Countermeasures

One of the objectives of this study was to determine whether information obtained by examining the driver's perception of the rear-end crash offered a way of conceptualizing potential countermeasure for these crashes. We reviewed the results and found that the classification of self-reported, explanation-based contributing factors provided the best framework for the development of countermeasure concepts. Each explanation-based contributing factor lent itself to at least one concept for countermeasure development. In this section we present each countermeasure as a function of the type of self-reported cause for the crash it is designed to counteract.

Normative Incorrect Driver Assumptions

Several of the crashes reported by the subjects in this study occurred when the driver was faced with a stopped vehicle in an unexpected location and made the wrong assumption about the motion of the vehicle. The drivers assumed that the car was moving. An unambiguous indication of the stopped status of the vehicle was clearly needed. Systems that convey this information could be useful in reducing this type of crash.

Automatic Hazard Lights: An easily implemented system is an automatic hazard light system that comes on when the car engine is running, the car is not moving, and the emergency brake is engaged or the car is in park. With this system, vehicles that have stopped for an unknown reason in a travel lane would be clearly identified as not moving. Since the system would only engage when the car is in park (or the emergency brake is applied), it would not engage in stop-and-go traffic or for vehicles stopped at signals or stop signs.

Non-Normative Incorrect Driver Assumptions

Examining the self-reported reasons for these types of crashes, indicated that the crashes due to non-normative incorrect driver assumptions were most frequent among the youngest group of subjects, i.e., those 25 years of age or less. Much research has shown that many drivers in this age group are inexperienced and engage in risky driving behavior. According to a recent cognitively-based model of risky driving (Eby and Molnar, in press) some of these young drivers may engage in risky-driving behaviors because they are risk taking (i.e., they perceive the risk and do it anyway), and others engage in this behavior because they are risk ignorant (i.e., they do not perceive the risk in their behavior). Those who are risk ignorant can become safer drivers by having a better understanding of the risk inherent in their driving behaviors. Thus, the results suggest that the non-normative incorrect assumptions made by drivers in our study may derive from inexperience with various traffic situations or from ignorance of traffic risks. If so, the results suggest that focused training could help to increase safe driving behaviors.

Electronic Hazardous-Driving-Action Feedback: The purpose of this system would be to provide individualized feedback to a driver at the end of a trip. The system would monitor a vehicle's headway over an entire trip and determine when the driver was following too closely for the speed and environmental conditions. At the end of a trip the system would provide the driver with some type of feedback about his/her driving. Example feedback might include the percentage of the trip in which the driver was following too closely and an associated crash risk. The risk of injury during the trip might also be conveyed to the driver, based upon the crash risk, safety belt use, and driver age and sex.

The crucial elements of the feedback are that it is accurate and individualized. The form, content, and timing of the feedback would need to be determined empirically using simulators and on-the-road experiments with subjects from various demographic populations.

Do-Not-Accelerate-Now System: Analysis of the self-reported, non-normative incorrect assumptions showed that in many of these cases the driver incorrectly assumed that the lead vehicle had started to move when it had not. A system that would prevent the stopped following vehicle from moving if there was a stopped lead vehicle in front of it (at some specified short distance) might have helped to prevent some of the rear-end crashes reported in this study.

Divided Attention

Problems with divided attention appeared to be the cause of a large portion of the crashes reported by the subjects in this study. Drivers were either preoccupied or were trying to do something else while driving. Systems that would eliminate some of the reasons that their attention was diverted from the driving task would help in this case, as would systems that reduced the effort that the driver had to devote to the second task. Systems that helped to teach drivers how to efficiently divide their attention would also be useful.

Front-Seat Cargo Holder: According to the subjects, some rear-end crashes occurred when drivers dropped an item they were carrying, either in their hands or on the front-passenger seat, and reached down to pick it up. People often put items on the front seat or have to deal with beverage containers that are too big for the provided cup holders. Simply providing them with a device to safely and securely hold items that they do not want to put in the trunk or back seat would reduce the need for them to bend down to pick up items when they are dropped or fall off of the seat. The device could be as simple as a package holder that can be quickly adjusted to hold various shapes and sizes of items and is attached to the front passenger seat. The device would, of course, need to be crash-tested and designed with safety in mind.

In-Vehicle Street Signs: According to the subjects, some rear-end crashes occurred because the driver was looking at street signs and not at the traffic flow. A system that brought this information into vehicles would enable drivers to locate and read signs without turning their heads away from the traffic. An additional feature of a system such as this is that it could also display the traffic control signs inside the vehicle--another self-reported reason for rear-end crashes in this study.

Neck Flexibility Training: Several middle-age and older subjects reported that their rear-end crash occurred when they were looking over their shoulders to check their blind spot. Since it is well known that flexibility declines in older adults (see, e.g., Eby et al., 1998), these subjects may have had difficulty performing this movement because of decreased flexibility. The direct solutions to this problem (mirror systems and proximity detection systems) are either currently available or are in development. A different approach to this problem would be to implement a flexibility training program that was designed specifically to improve flexibility and strength for the maneuvers needed for safe driving, such as neck turning.

Hazardous Situation Detector: Some of the younger subjects reported that they were thinking about other things at the time of their rear-end crashes. Assuming that people of all ages are thinking about other things while driving, this self-reported factor in the crashes of young people may indicate that, because of inexperience, their driving task is less automated, thus requiring greater attention for safe operation of a vehicle. In addition it is well known that young drivers have greater difficulty than others in identifying hazardous traffic situations as they are developing driving experience. The slightly preoccupied younger driver would have less attention to devote to perceiving hazards, when even with full attention they have difficulty with this task. A solution to this problem is to obtain more experience in recognizing hazards. Again, the direct approach to this problem, to have the younger driver gain the experience in a setting that is relatively safe such as a simulator, have already been implemented. A different approach is to design an on-the-road system that identifies specific situations that have a high probability of being hazardous and then warns the driver or asks if he or she sees it. This concept would have to be explored empirically before any specific recommendations could be made.

Unavoidable Crashes

Large Vehicle Lane Restriction: As mentioned earlier, several of the subjects reported that their rear-end crash was unavoidable and resulted from the actions of drivers several vehicles ahead, which they could not see. One reason mentioned for the inability to see the actions of vehicles more than one vehicle ahead was that the vehicle immediately in front of the driver was a van, minivan, pick-up truck, or sport-utility vehicle. Requiring these vehicles to stay in certain lanes, perhaps in high-traffic areas, would allow drivers of passenger vehicles to be able to see traffic movement more than one vehicle ahead. Lane restriction for large trucks is already implemented in many areas.

Ban Darkened Rear Windows: Another reason mentioned for the inability to see the actions of vehicles more than one vehicle ahead was that the vehicle immediately in front of the driver had a darkened rear window. An obvious countermeasure is to ban these types of windows.

In-Vehicle Display of Traffic Patterns: Another way to allow the driver to have information about the movement of vehicles more than one vehicle ahead is to bring this information into the vehicle electronically. It is possible that the systems that sense lane occupancy and speed of vehicles for freeway surveillance systems could be used to communicate lane occupancy and vehicle speeds to a device in the vehicle. Again, the type of system, algorithms, and situations that constitute potential hazards, and message form, content, and timing would need to be thoroughly researched.

Conclusions

This pilot study has demonstrated that examining the crash from the point of view of the driver was a somewhat fruitful approach to coming up with concepts that could be developed into countermeasures. In this study, only rear-end crashes were investigated. The study approach could be applied to other crashes to develop countermeasure concepts for different types of crashes. However, it is important to note that many of the self-reported reasons for the crashes (both question-based and explanation-based) could have been derived solely from the available crash statistics.

Given the study findings and the rear-end-crash-countermeasure concepts that have been proposed, the next step is to present these concepts to a group of experts for feedback and revision. The most promising and innovative concepts should then be selected and studied further. For example, the electronic hazardous-driving-action feedback system takes an approach to potentially reducing rear-end and other crashes that is unique from current approaches. This concept has to be tested with actual drivers. The concept could be quickly tested with a mock-up system using various types of available technology to see if the countermeasure has potential for further development. The effect of different feedback information on positively changing driving behaviors would also have to be empirically determined.

REFERENCES

Eby, D.W. and Molnar, L.J. (In press). *Matching Safety Strategies to Youth Characteristics: A Literature Review of Cognitive Development.* (Technical Report). Washington, DC: US Department of Transportation.

Eby, D.W., Trombley, D.A., Molnar, L.J., and Shope, J.T. (1998). *The Assessment of Older Drivers' Capabilities: A Review of the Literature*, (UMTRI Report No. 98-24). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Bernstein, D.A., Roay, E.L., Scrull, T.K., and Wickens, C.D. (1991). *Psychology, 2nd Edition.* Boston, MA: Houghton Mifflin.

APPENDIX A:

Moderator's Guide

Moderator's Guide

Introductions
Lead-in: roles/rules in focus group
This is a research project which looks at the crash from the drivers perspective. We have looked at statistics, now we want to know what the drivers think happened. By knowing what the driver saw, heard, didn't see, didn't hear, we can think about features that may prevent such crashes in the future.

1. I'd like you to think back to the time of your crash,
tell us the circumstances and tell us what happened.

Points to be covered?

- When did your crash occur (day, night, rush hour)?
- What was the purpose of your trip?
- Where you in a hurry?
- Where was the crash (city, suburbs, small town, mall, ramp, rural, speed limit)?
- Was your crash at an intersection (signal, stop sign, yield sign, no sign)?
- Was it on the road (not at an intersection)? What type of a road was it? Where there grades, curves? How fast were you going? How close together were the cars?
- What was the weather (rain, snow, sleet, no weather problems)?
- Did you have vehicle problems?
- Who was with you in your car? What were they doing?
- What you were doing?
- Do you remember what you were thinking about? If yes, what?
- What happened?
- What were the actions of the other car?
- What type of vehicle was it? Who was driving it? How many people were in it?
- What was the damage?

2. Why do you think your crash occurred? What do you think the reasons are? Why do you think so?

Do you think any of the following contributed to the crash? - how much?

- vehicle problems
- the weather - visibility
- road surface - slippery, wet, icy, snow covered
- the road itself - curves, hills, couldn't see
- road signs - confusing
- the traffic signal
- actions of the other driver (Did you assume that the driver of the car was going to do something that he/she did not do?)
- passenger interference
- personal error

- other distraction - what kind?
- other

3. Were you aware of the other car before the crash?
   Did you see it? Did you hear it?

4. Did you have any clues that there was a problem? What were they? Did you hear, see, sense anything unusual?

5. What was going through your mind at the time of the crash?

6. Do you think this type of crash is unusual or fairly common? Why do you think so?

7. Think about your crash and crashes like it. What do you think would help you and others avoid crashes of this type?

8. If you had more time to react, could you have avoided the crash? How much more time?

Do you think a warning system of some type would help to avoid such crashes? What kind of warning do you think would help?

9. What about a system that lets you know that there is a vehicle within some distance of your vehicle? Do you think that would help?

What do you think of a system that monitored the distance between cars and gave you a warning if the space between your car and the one in front was closing too rapidly for the speed at which you were traveling? Would you consider using it?

10. How about a system that monitored whether you were falling asleep? Do you think it would have helped you or others that experienced similar crashes?

11. Would you be willing to try out such warning systems? Would you consider buying any of these systems as options on your car? How much would you be willing to pay such systems? (Proximity warning system, closing distance warning system, sleep monitoring system)

APPENDIX B:
Letter to Potential Subjects And Informed Consent Form

The University of Michigan
Transportation Research Institute
2901 Baxter Road, Ann Arbor, Michigan 48109-2150

July 13, 1998

John Smith
100 Main Street
Some City, MI 48100

Dear Mr. Smith:

The University of Michigan Transportation Research Institute is studying ways to help prevent rear-end crashes. As part of this study we want to talk to drivers who have recently experienced such a crash. We received your name from the State of Michigan Vehicle Accident Records and would like to invite you to participate in a focus group of drivers who have had a similar experience. In about a week, one of our researchers will call to see if you would like to participate in this study.

A focus group is a structured group interview of people who have something in common. If you take part in this study, you will participate in one focus group session for approximately 1 hour you will be asked to talk about your experience in the rear-end crash, for example, what you, what you heard, what clues you had or did not have that something was wrong, and son on. The atmosphere will be friendly and congenial and you will receive a payment of $35 for your participation. You will also be asked to sign an informed consent form, a copy of which is enclosed for your review.

Any information you provide will be considered strictly confidential and will be used only for the purposes of this study. Your name will never appear in any study publication. If you have any questions about this study, please call Dr. Lidia Kostyniuk, the project director, at 734-763-2466. She will be happy to assist you.

Sincerely yours,

Carl Christoff
Research Associate

Enc. Informed Consent Form

INFORMED CONSENT FORM

EXPLORING REAR-END ROADWAY CRASHES FROM
THE DRIVER'S PERSPECTIVE

The purpose of the research study is to gain an understanding of rear-end vehicle crashes from the driver's perspective by gathering information from people who have recently experienced such a crash. Ultimately, this information will be used to help vehicle designers develop systems that help drivers to avoid such crashes.

We are recruiting approximately 60 individuals who are 18 years of age or older and that have been involved in a rear-end crash in the last two years. Subjects will participate in a focus group for approximately one hour on a single occasion. A focus group is a structured group interview of people who have something in common. You can talk about your experiences in the rear-end crash, for example, what you saw, what you heard, what clues you had or did not have that something was wrong. The atmosphere during the focus group should be friendly and congenial.

The focus group will be videotaped and the image of the subject on the videotape may provide linkage to the subject. The videotapes will be stored in a locked file accessible only to the research project staff. After the videotapes are analyzed, they will be destroyed.

State law protects University of Michigan Transportation Research Institute data from being used in any Civil or Criminal action but since focus groups are being used for this research, a member of the focus group could tell others what was said during the focus group discussions. In order to lower the chance of this disclosure, every member of the focus group will be asked to keep all information discussed confidential.

The only risks to you associated with your participation in this study are those associated with taking part in a group discussion. The benefits to you and others may be an increased understanding of the factors that contributed to your rear-end crash.

All information received from you will be held confidentially and no individual or identifying information will be released. You will be paid $35.00 for your participation and you may gain insights into your rear-end crash. You can withdraw from this study at any time without penalty. For more information about this study, including your rights as a subject, you may contact Dr. Lidia Kostyniuk, Ph.D., University of Michigan Transportation Research Institute, 2901 Baxter Rd., Ann Arbor, MI 48109-2150. Phone (734)763-2466.

One copy of this document will be kept together with the investigators' research records on this study. A second copy will be given to you to keep.

I have read and understand the information presented above. I understand my that participation in this study is entirely voluntary and that I may withdraw at any time without penalty.

Subject's Name:
Birth Date:
Signature:
Date:

I have given this research subject information on the study, which in my opinion is accurate and sufficient for the subject to understand fully the nature, risks and benefits of the study, and the rights of a research subject. There has been no coercion or undue influence. I have witnessed the signing of this document by the subject.

Witnessed by: Signature: Date:

APPENDIX C:
Demographic Questionnaire and Subject Demographics

Demographic Questionnaire

1. How many years have you driven? ___________

2. How many miles do you drive in a year? __________

3. What type of a car do you drive:

____ Passenger car
____ Sport utility vehicle
____ Pick-up truck
____ Minivan
____ Station wagon
____ Full size van
____ other, please specify __________________

4. Are you male____ female_____

5. How old are you? _________

6. What is the highest level of education you have completed?

____ Less than high school
____ High School diploma or equivalent
____ Some college
____ College Degree
____ Some graduate education
____ Graduate degree or higher

7. Which category best describes your annual household income for 1997?

____ less than $14,999
____$15,000 to $29,999
____$30,000 to $49,999
____$50,000 to $64,999
____$65,000 to $79,999
____$80,000 to $94,999
____$95,000 to $109,999
____ over $110,000

Thank you for participating in our study of drivers' viewpoints of crashes!

Subject Demographics

How Many Years Have You Driven?	Age Group		
	18-to-24	25-to-64	65-and-over
Mean	7.1	27.4	53.6
SD	2.2	14.4	9.8
N	9	5	11

How Many Miles Do You Drive in a Year?	Age Group		
	18-to-24	25-to-64	65-and-over
Mean	16,550	17,000	13,590
SD	1,232	7,079	6,964
N	10	5	11

What Type of Car Do You Drive?			
Vehicle Type	Age Group		
	18-to-24	25-to-64	65-and-over
Passenger	7	3	6
Sport Utility	2	0	1
Pickup Truck	0	0	0
Minivan	0	0	0
Station Wagon	0	0	1
Full Size Van	1	0	0
Other	0	2	3
TOTAL	10	5	11

Are You Male or Female?			
Sex	Age Group		
	18-to-24	25-to-64	65-and-over
Male	3	3	5
Female	7	2	6

How Old Are You?	Age Group		
	18-to-24	25-to-64	65-and-over
Mean	23.4	43.0	73.7
SD	1.9	14.5	5.7
N	10	5	11

What is the Highest Level of Education you Have Completed?			
Education Level	Age Group		
	18-to-24	25-to-64	65-and-over
Less than High School	0	0	0
High School Diploma/Equivalent	0	0	2
Some College	7	3	4
College Degree	2	0	1
Some Graduate Education	1	0	1
Graduate Degree or Higher	0	2	3
TOTAL	10	5	11

What Best Describes Your Annual Household Income?			
Annual Household Income	Age Group		
	18-to-24	25-to-64	65-and-over
less than $14,999	1	0	0
$15,000 - $29,999	5	0	3
$30,000 - $49,000	3	1	6
$50,000 - $64,999	1	0	0
$65,000 - $79,999	0	2	1
$80,000 - $94,999	0	1	0
$95,000 - $109,999	0	1	0
more than $110,000	0	0	0
missing	0	0	1
TOTAL	10	5	11

APPENDIX D:
Summary of Self-Reported Crash Information

SUMMARY OF SELF-REPORTED CRASH INFORMATION

Sex-age* of subject	location of crash	traffic	action of lead vehicle as reported by subject	self-reported actions of striking driver/ vehicle	classification of self-reported cause **	Self-reported contributing factors	classification of self-reported contributing factors **	Subject's ideas on what could have prevented the crash
male-20	street non intersection	heavy	stopped because vehicles ahead stopped	preoccupied with exam slid into car ahead	divided attention	slippery road	environment	device that warns about distance to car ahead
female-20	street intersection	normal	standing at intersection	assumed she could stop	non normative incorrect assumption	thought there was enough room to stop	personal error	if I had more time, I could have avoided crash
female-21	street non intersection	normal	stopped because vehicles ahead stopped	did not realize lead car was stopped	divided attention	actions of other driver, slippery surface, level of attention	environment (33.33%) actions of other driver (33.33%) personal error (33.33%)	if drivers left more room between cars and paid more attention to driving
female-22	street intersection signalized	heavy	standing at intersection	assumed lead car was moving	non normative incorrect assumption	actions of other driver, wet surface, not paying enough attention	environment (33.33%) actions of other driver (33.33%) personal error (33.33%)	if drivers kept distance between cars, paid attention to weather, environment, and everything
female-24	street intersection signalized	normal	standing at intersection	assumed her signal was green and lead car would move	non normative incorrect assumption	inattention, placement and timing of signals	road design (33%) personal error (67%)	if drivers paid more attention to driving
female-24	freeway ramp	normal	standing in lane	did not know car was stopped/ not enough time to stop	normative incorrect assumption	design of freeway ramp, actions of other driver, rain and fog,	road design (50%) environment (15%) actions of other driver (35%)	if the design of freeway ramp was better or left room for recovery
male-24	street non intersection	heavy	stopped because vehicles ahead stopped	distracted by jaywalkers, assumed lead car should be moving	non normative incorrect assumption	actions of other driver	actions of other driver	if drivers were better

Sex-age* of subject	location of crash	traffic	action of lead vehicle as reported by subject	self-reported actions of striking driver/ vehicle	classification of self-reported cause **	Self-reported contributing factors	classification of self-reported contributing factors **	Subject's ideas on what could have prevented the crash
female-25	freeway lane	heavy	stopped because vehicles ahead stopped	tried to stop	unavoidable	actions of other driver	actions of other driver	brake lights that indicate whether car is stopped or moving
male-25	freeway lane	heavy	stopped because vehicles ahead stopped	preoccupied with other matters	divided attention	actions of other driver, preoccupation	actions of other driver (67%) personal error (33%)	fewer cars on the road
female-26	street intersection signalized	normal	standing at intersection	assumed stopped cars would be moving when she got there	non normative incorrect assumption	slippery road, inability to handle to situation (panicking)	environment (50%) personal error (50%)	no idea
male-28	street non intersection	normal	changed lanes and stopped because cars ahead were stopping	tried to stop	unavoidable	actions of other driver	actions of other driver	device that lets you know if car ahead is stopped or moving
male-34	street intersection signalized	heavy	standing at intersection	assumed lead car had made a right-on-red turn	non normative incorrect assumption	actions of other driver, misjudgment	actions of other driver (50%) personal error (50%)	if I looked sooner, I could have avoided crash
female-38	street intersection signalized	normal	changed lanes and stopped because of police car presence	assumed lead car would go through yellow light	normative incorrect assumption	actions of other driver	actions of other driver	if people drove better, if enforcement was better
female-52	freeway merge	heavy	stopped because vehicles ahead stopped	looking over shoulder	divided attention	road design - freeway merge area a "mixing bowl"	road design	if I had more time, I could have avoided crash
male-64	street intersection signalized	heavy	changed lanes and stopped at signal	tried to stop	unavoidable	actions of other driver	actions of other driver	if I had more time I could have avoided crash

Sex-age* of subject	location of crash	traffic	action of lead vehicle as reported by subject	self-reported actions of striking driver/ vehicle	classification of self-reported cause **	Self-reported contributing factors	classification of self-reported contributing factors **	Subject's ideas on what could have prevented the crash
female-67	street non intersection	normal	standing in travel lane	attending to cup of water	divided attention	paying attention to the cup	personal error	if other car was not there
female-68	street intersection	heavy	standing at intersection	watching gaps/ assumed lead car moved	non normative incorrect assumption	actions of other driver	actions of other driver	better road design and signing
male-69	street intersection signalized	heavy	standing at intersection	assumed lead car had moved	non normative incorrect assumption	inattention	personal error	device that will not let you move if car in front is not moving
male-69	street non intersection	normal	stopped because vehicles ahead stopped	looking at street sign	divided attention	glancing at sign, too close to car ahead	personal error	no idea
male-72	freeway lane	normal	moved over to reveal stopped car in travel lane	could not move over because of traffic	unavoidable	actions of other driver	actions of other driver	restrict big vehicles to their own lanes
female-73	street non intersection	normal	stopped suddenly to pick up pedestrian	surprised by sudden stop of lead car	unavoidable	actions of other driver	actions of other driver	no idea
female-73	street non intersection	normal	erratic movements - parking?	confused by actions of lead car	unavoidable	actions of other driver, my carelessness	actions of other driver (50%) personal error (50%)	if I left more room between me and car ahead
female-78	street intersection signalized	normal	standing at intersection	brakes failed	unavoidable	ABS brakes	vehicle problems	no ABS brakes
male-80	freeway lane	heavy	stopped because vehicles ahead stopped	tried to stop	unknown	actions of other driver	actions of other driver	no idea
male-82	street intersection signalized	normal	standing at intersection	not aware of lead car	divided attention	actions of other driver	actions of other driver	no idea
female-83	street intersection signalized	heavy	standing at intersection	picking up dropped roses	divided attention	reached for roses, released brake	personal error	if I did not try to pick up the roses

* Note, this is the subject age at time of interview in July, August, 1998. Crashes occurred in 1996.
**The classification of self-reported factors and causes is based on careful review of the enitre taped record of the interviews.