

## Information for Helping Drivers Achieve Safe and Enjoyable Driving: An On-Road Observational Study

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In this study, a series of on-road observations were conducted to derive information necessary for safe and enjoyable driving. Four pairs of participants were chosen from among those responding to a Web survey and attending a follow-up interview. Each pair was asked to drive six routes. Three of the routes were familiar to one of the pair and new to the other, with the former serving as navigator and the latter serving as driver. For the other three routes, the roles were reversed. Three interviews were conducted, one coming after two drives in which the pair played both roles, in order to derive information considered necessary for safe and enjoyable driving by the participants who served as driver on routes unknown to them. Three kinds of information for safe and enjoyable driving were identified: 1) guidance for routing, 2) support for safe driving, and 3) provision of miscellaneous information, such as information about daily topics of interest to the driver and information about interesting things to see along the route.

### INTRODUCTION

The primary purpose of driving is to transfer persons or things from one place to another. The primary mission of the driver is to control the vehicle safely. This may include the achievement of objectives such as energy efficiency, punctuality, and so forth, as optional missions. Traditional car navigation systems are expected to provide information that helps drivers to accomplish their mission of maneuvering satisfactorily. However, with the advent of telematics, modern car navigation systems have begun providing location-based information, such as recommendations of local restaurants along the route. The infrastructure enabling the provision of location-based and context-sensitive information is being developed, making it possible to provide information to drivers that would allow them to experience more safe and enjoyable driving in terms

of not only the maneuvering mission but also a variety of concerns encountered en route (e.g., Satou et al., 2007).

Technological development is very rapid, and it will be possible in the near future to provide information that is necessary for drivers in order to make safe and enjoyable driving. However, what is lacking at the moment is knowledge concerning what information is actually needed by drivers. Due to this problem, the provision of information by the modern car navigation systems is not completely appropriate (Tahira and Mine, 2004; Tahira, 2006). The content of the provided information is not what the drivers actually need, and therefore the provided information may be evaluated as annoying. In other cases, the information is not provided in a form that the driver can easily understand, e.g., the driver may prefer “*distance to the intersection to turn*” over “*the number of blocks to the intersection to turn*.”

The purpose of this paper is to describe a series of on-road observations that were conducted to elucidate the nature of information that drivers consider necessary to make safe and enjoyable driving. This knowledge should provide a basis for designing an information-provision service for safe and enjoyable driving. This paper provides a list of such information based on the results of the on-road observations. Some kinds of information can be easily provided by applying currently available or developing technology, whereas other kinds will require extensive technological development.

## ON-ROAD OBSERVATIONS

### Outline of the Study

We conducted a series of on-road observations to extract information necessary for safe and enjoyable driving. Four pairs of participants joined the study. The two persons in each pair were acquainted with each other very well and knew each other's driving attitude and knowledge about driving, so they were expected to provide information necessary for safe and enjoyable driving to the driver when their partner was driving an unfamiliar route.

Each pair participated in three sessions. Each session had a different purpose, which will be described in detail in the next subsection. Each session consisted of a set of two on-road drives with driving times ranging from 30 to 90 minutes, followed by an interview. The purpose of the interview was to determine the information needed for safe and enjoyable driving. Each drive was videotaped using two digital video cameras (see Fig. 1); one for the outside view (camera B), and the other for the driver and navigator view (camera A).

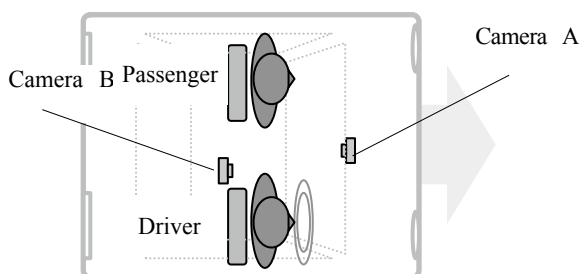


Figure 1. Experimental setup.

In the first drive, one member of the pair drove a route that their partner was completely familiar with. The partner thus served as a *human* navigator who was expected to provide information that would cause the driver to make safe and enjoyable driving. In the second drive, the roles were reversed, that is, the person who drove in the first drive now served as the navigator, and vice versa.

### Procedures

*First session.* The navigator was expected to provide information necessary for safe and enjoyable driving to the partner, *i.e.*, the driver, by imagining that he or she, the navigator, was driving this familiar route and estimating the degree of its necessity using his or her own criteria. However, since the navigator did not know perfectly what information was actually needed by the driver, some information would not be perceived as necessary. Therefore, the purpose of the first session was to “know each other better in order to provide information that is actually necessary for safe and enjoyable driving.” The interview immediately after the two drives was designed to facilitate this know-each-other learning. However, the learning was case-based. Thus, the acquired knowledge was not general enough to be applied to similar situations that do not exactly match the learned ones.

*Second session.* As a result of the first session, the navigators were expected to have acquired case-based knowledge as to which information was perceived by the drivers as necessary for safe and enjoyable driving. The second session asked the navigators to utilize this set of knowledge. In the interview session, their driving was reviewed, and thus it should have helped the navigators to strengthen their case-based knowledge. In addition, the navigators were provided with a list of generalized information that we derived by analyzing the instances when information was needed for safe and enjoyable driving. For example, a concrete instruction “turn right at the second traffic light” could be generalized to an expression such as “use traffic lights or landmarks when instructing.”

*Third session.* The lists of generalized information were handed to the navigators in order to make sure that the listed information would be provided to the drivers.

## Recruiting the Participants

The study was conducted from October 2007 to February 2008. It was crucial for this study to recruit participants who were good at providing information for safe and enjoyable driving to the driver. Therefore, we adopted a two-stage recruiting process consisting of a Web questionnaire for screening and an interview for the final selection.

*Screening.* Questionnaires were distributed to 1,655 individuals who met the following conditions: 1) he/she lives in the metropolitan area of Tokyo; 2) his/her age is between 20 and 50; and 3) he/she drives his/her car more than twice a month. Some questions requested them to self-estimate their skill in providing the information necessary for safe and enjoyable driving, such as *Are you an officious person?*, *Are you an industrious person?*, or *Are you a considerate person?* A respondent was asked to accompany a person who would participate in the driving sessions. He/she answered these questions on behalf of his/her partner.

The responses were analyzed to select candidate pairs for the on-road observational study. The judgment criterion was whether both the respondent and his/her partner would be able to provide information that was necessary for safe and enjoyable driving while one of them was navigating and the other was driving. Note that both members of the pair would play the roles of navigator and driver. Thus, each was expected to be a good information provider for the other. Ten pairs were selected as candidates for the on-road observations, then further examined in an interview, described below, for the final selection.

*Interview for the final selection.* There were several stages in the interview. First, the answers provided by the respondents were reviewed for their appropriateness. Each candidate pair was then asked to plan the routes for the three driving sessions. A total of six routes were provided. A requirement for

each route was that the route was completely familiar to the navigator and yet was new to the driver. In addition, it was anticipated that there would be a number of opportunities for the navigator to provide information necessary for safe and enjoyable driving. During the interview, the candidate pairs were asked to draw the routes on a board. The drawings were used to examine the appropriateness of the routes for this study with a face-to-face interview.

Following the examination of the responses of the candidate pairs, four pairs were selected for the on-road observational study. Three of the four pairs were married couples, and one was a pair of female colleagues who worked at the same company.

## RESULTS

### Data Analysis

A total of 24 maneuvers were videotaped and analyzed in order to derive the information provided by the navigators to the drivers. As a result, a total of 1,859 information sets were extracted.

*Data coding.* Each information set was represented using the following four descriptors: 1) the utterance, 2) the way the information was provided including the timing, and the way the direction was described, 3) the traffic conditions, such as the width of road, speed of the vehicle, *etc.*, and 4) the driver's condition, such as the workload of driving or any pre-existing knowledge about the route. The former was estimated by viewing the video and the latter was inferred during the interviews.

*Evaluation of the provided information.* In the interviews, each information set was evaluated by the driver as to whether it was effective in helping him/her to conduct safe and enjoyable driving. In addition, likely rationale for the evaluations were attached when possible. However, it was not possible to allocate enough time to review all of the information, so parts of the provided information were not reviewed thoroughly. We evaluated such information by ranking them at one of the following levels: 1) The information was judged as *good* because it seemed necessary for the driver to conduct safe and enjoyable driving, 2) The information was

judged as *average* because it was not likely to have affected the driver's behavior, and 3) The information was judged as *poor* because it seemed that the driver responded negatively.

### Information Necessary for Safe and Enjoyable Driving

Items evaluated as *good* were extracted from the whole set of provided information and further classified into three categories: 1) Guidance for routing, 2) Support for safe driving, and 3) Provision of miscellaneous information. In the following subsections, the subcategories of these categories will be described in detail.

*Category 1: Guidance for routing.* There are nine subcategories under this category.

1) Information that specified the point of action by using an easy-to-understand reference for the driver (see *Episode 1* for a detailed example).

2) Information that was useful in planning future actions.

3) Information whose expression was crafted by selecting words that were comprehensible to the driver.

4) Information that augmented the driver's knowledge about the route.

5) Information that specified a route that the driver preferred.

6) Suggestions of drop-by places made by considering the driver's condition.

7) Suggestions of parking places that made the activities undertaken after getting out of the car easier.

8) Timely provision of information that made the driver feel comfortable and relieved.

9) Information that confirmed an action that the driver had carried out according to the navigator's directions.

*Category 2: Support for safe driving.* There are seven subcategories under this category.

1) Information that helped the driver resolve undecided situations, leading to safe driving.

2) Information that caused the driver to pay attention to events for safe driving (see *Episode 2* for a detailed example).

3) Information that helped the driver prepare for future actions, ensuring safe and smooth driving (see *Episode 3* for a detailed example).

4) Actions carried out by the navigator that otherwise would have had to have been carried out by the driver.

5) Checks for traffic conditions carried out by the navigator that otherwise would have had to have been carried out by the driver.

6) Pointing out actions missed by the driver.

7) Reflections on improvements in driving behavior.

*Category 3: Provision of miscellaneous information.* There are two subcategories under this category.

1) Information about daily topics of interest to the driver.

2) Information about interesting things seen along the route (see *Episode 4* for a detailed example).

### EXAMPLES

In this section, four episodes involving the provision of information that was perceived by the driver as necessary information for safe and enjoyable driving will be demonstrated.

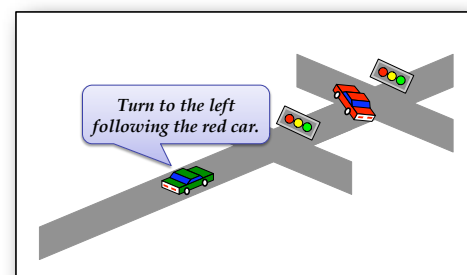


Figure 2. Episode 1: Information that specified the point of action by using an easy-to-understand reference for the driver.

*Episode 1: Information that specified the point of action by using an easy-to-understand reference for the driver (see Fig. 2).* When there was a leading vehicle, the navigator provided routing information by using the leading vehicle as the reference. The area where this guidance was provided had a num-

ber of traffic lights and intersections. Therefore, it was not easy for the first-time driver to identify the exact location to make a turn. Thus, this information was evaluated as highly valuable by the driver.

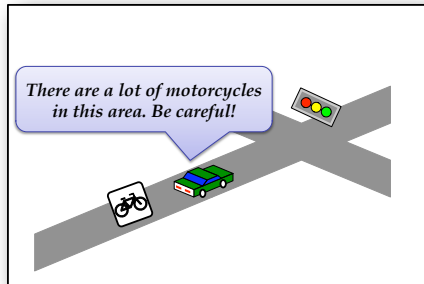


Figure 3. Episode 2: Information that caused the driver to pay attention to events for safe driving.

*Episode 2: Information that caused the driver to pay attention to events for safe driving (Fig. 3).* The navigator told the driver that he/she should pay attention to motorcycles that would likely pass on the driver's side of the car. This area was near a university campus and many students had motorcycles.

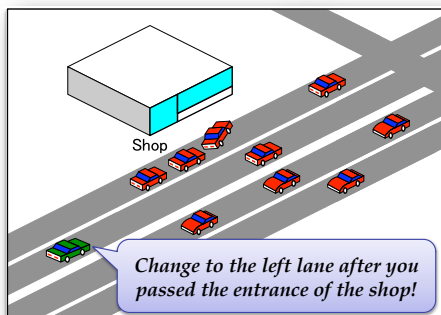


Figure 4. Episode 3: Information for safe and smooth driving. Note that cars drive on the left lanes in Japan.

*Episode 3: Information that helped the driver prepare for future actions, ensuring safe and smooth driving (Fig. 4).* When the driver was about to make a lane change from the current driver-side lane to the passenger-side lane in order to prepare for the next left turn, the navigator suggested remaining in the driver-side lane until the car had passed a mass home-electronics retailer because it was likely that the passenger-side lane would be jammed with cars going to the retailer.

*Episode 4: Information about interesting things seen along the route.* The navigator introduced the driver to a bakery where a variety of excellent breads were sold at reasonable prices. The navigator knew that the driver was interested in bread and that this information would be highly valuable for her.

## CONCLUSION

This paper has identified three categories and eighteen subcategories of information that drivers evaluate as necessary for safe and enjoyable driving. The ultimate purpose of this study was to combine the informational needs of drivers for safe and enjoyable driving as derived by the method this paper describes with technological solutions that will make this happen.

For example, for a driver who does not know the area and is not good at merging and changing lanes, it would be useful for him to be given such instruction as "change to the left lane now because there is a merge from the right shortly." This is technologically feasible if there exists a system that can judge whether the following conditions are met: 1) the car is driving on the right lane, 2) there is a merge on the route, and 3) it is possible to change to the left lane considering the current traffic condition, and the system can know the driver's attributes as described above.

In the past, little serious effort has been expended on matching drivers' informational needs with technological considerations. The informational needs this paper has identified, however, are not comprehensive. More studies will be necessary to investigate drivers' informational needs covering all driving situations.

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