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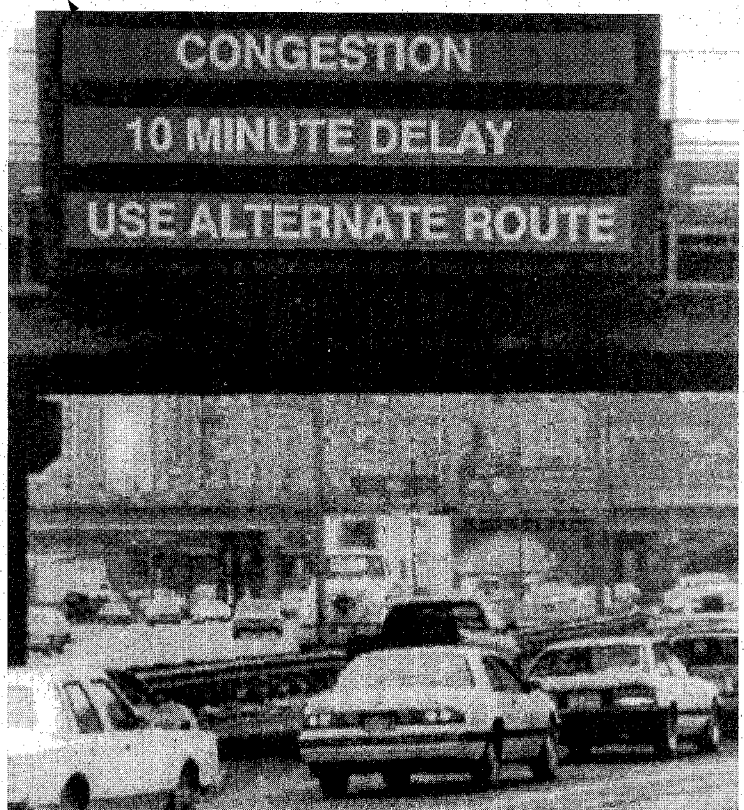

Following Advice from Traffic Advisories

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16. Abstract (Limit: 200 words)

This report presents data using multiple-choice questionnaires to learn how drivers respond to traffic information in the form of advisory messages. Two experiments, comprising 112 participants, were conducted using the same technique and yielding similar results. The traffic information messages presented to participants varied in three respects; quantitativeness of information, imperativeness of advice, and timeliness of information. Two additional factors were examined; the amount of traffic congestion stated to be directly observable on the route and the stated accuracy of messages received in the past.

Results obtained from the questionnaires indicate that the structure of the traffic message did influence the driver behavior. The propensity to depart from the planned route ahead of schedule was greater when respondents had; few exit options remaining, been told traffic levels were high, received accurate traffic information in the past, and had received messages which contained quantitative and/or imperative information.

Traffic controllers with this knowledge of driver behavior could act to further reduce trip times and congestion by using the control tools currently available to them. The major conclusion we can draw from this study is that when possible and appropriate, advisory messages should contain accurate, timely, quantitative and imperative information.

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FOLLOWING ADVICE FROM TRAFFIC ADVISORIES

Final Report

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EXECUTIVE SUMMARY

As Intelligent Vehicle Highway Systems (IVHS) technology is introduced, we can anticipate that the amount of traffic information and advice made available to travelers will increase. Even with the limited amount of information and advice available now, we do not know how travelers respond to it. Nor do we know how to structure information and advice in order to receive a predictable response from travelers. The objective of this study was to determine how travelers respond when confronted with information and advice about traffic conditions and the means for avoiding congestion. It was our contention that the structure of traffic advisory messages would influence travelers' responses.

The idea that led us to undertake this experiment was shown to be correct. Drivers respond differentially to advisory messages based on the quality and quantity of information contained in the message. In particular, quantitative and imperative information cause adaptive responses from drivers. By adaptive responses we mean that drivers would act to reduce congestion thus lowering trip times. Furthermore, the accuracy of traffic information received in the past influences driver behavior. There is a positive relationship between past message accuracy and adaptive responses by drivers.

Traffic controllers with this knowledge of driver behavior could act to further reduce trip times and congestion by using the control tools currently available to them (e.g., ramp meters, traffic signals at intersections and Changeable or Variable Message Signs). The major conclusion we can draw from this study is that when possible and appropriate, advisory messages should contain accurate, timely, quantitative and imperative information.

INTRODUCTION

Travelers in the Twin Cities Metro area can receive advice and information about traffic conditions and alternative routing. This information can be obtained in three ways prior to or during the trip: ordinary radio/television broadcasts of public service advisories, special radio frequencies (FM 88.5) for traffic information, and a few Changeable/Variable Message Signs (CMS/VMS) on major roads. In the future we expect that the amount, availability, timeliness and thus usefulness of this information will increase. The technology to support this increase exists now. We can even imagine that dynamically updated databases will supply information, perhaps via satellite, to in-car navigation systems which will provide current routing relevant to each driver's announced origin and destination. No such service is currently available in the Twin Cities Metro area. Until it is, we can hope for improvements in the dissemination of traffic information by radio, TV and CMS/VMS. Such improvements may include the development and widespread application of some form of Radio Data Systems (RDS) and the types of traffic information and communication under evaluation in the Minnesota Department of Transportation's (MN/DOT) and their partners' Genesis Program.

Even with an improvement in information availability, we can continue to anticipate traffic congestion with resultant accidents. One reason for this is the rapid increase in the number of vehicles relative to the ability of the roadways to handle them. Improved traffic management systems based on more and better sensors, processors, communications and system architectures will alleviate but not prevent traffic congestion. With many others we hope that increasing the quality and quantity of information available to the traveling public will be an effective weapon in the traffic managers' armamentarium. However, much of this hope is predicated on the assumption that the traveling public will behave in a consistent manner with respect to traffic messages.

If drivers will not behave consistently with respect to traffic information, perhaps we should not undertake the expense of providing it. However, another view, and the view taken here, is that if we can learn what drivers (in the population not individual sense) will do, rational or not, upon receipt of traffic information, then we still have an opportunity to manage traffic more effectively than at present. In general how should advisories be couched so that traffic management systems can correctly predict drivers' behavior and thus better manage traffic? That is, we do not require individuals to perform with consistently and completely rational behavioral responses to advisories, rather we only need a way of quantitatively estimating population behavior. In the following, we suggest ways in which we can learn to predict drivers' responses to traffic advisories.

METHODS

Overview

The objective of this study is to determine how drivers respond when confronted with information and advice about traffic conditions and the means for avoiding congestion. Our plan was to collect data which would tell us how people would respond to traffic messages structured in various ways and in a small way to characterize the responders *vis a vis* biases which might influence their responses to the messages. To interpret clearly respondents' meanings when they were asked questions about predictions of their own behavior in response to traffic advisories, we had to bound the possible answers. One way to do this, and the way we used, was to develop a multiple choice questionnaire. We developed two separate questionnaires. The first of these was used in a pilot study (Experiment I). The second questionnaire was a streamlined descendent of the one used in the pilot study and was used in the primary experiment (Experiment II). Each questionnaire contained five components; (1) a map, (2) a set of scenarios, (3) a set of advisory messages, (4) a list of choices, and (5) a list of reasons for selecting a particular choice.

The main, alternate and connecting routes were depicted on a map which participants could refer to throughout the experiment. The scenarios placed the participants in particular settings, motivated their responses and provided an equitable footing among participants. Following each of the scenarios a series of advisory messages was presented. After each message was read, participants were required to select one choice indicating the action they would take upon receipt of that message. Finally, for each choice participants were asked to indicate a reason for making the choice they did. A detailed discussion of each of these components will be given later in this report.

Procedures

Persons participating in these experiments were asked to complete the experimental questionnaire and the Human Factors Research Laboratory's general information survey. In Experiment I respondents were scheduled in groups and completed the questionnaire and survey in our laboratory with an experimenter present to introduce the project, give instructions and answer questions. Upon completion of these two items participants received a ten dollar cash payment. In Experiment II packets were mailed to persons who had been screened by telephone conversations. The screening was to determine that they were licensed drivers familiar with the routes in question and that they were willing to complete the questionnaires. The packets contained instructions, questionnaire, survey, answer sheet, stamped return envelope and ten dollars. These participants were also given telephone numbers they could call at any time to get answers to procedural questions. (No such calls were received.)

Participants

Experiment I: Sixty-four licensed drivers were recruited for the pilot study. Qualification for participation was familiarity with the routes of travel designated in the questionnaire. This meant that most participants were faculty, students or staff on the University of Minnesota East Bank Campus. In this experiment age and gender were not included as variables and thus were not equally represented in the sample. Forty-three women and twenty-one men with an average age of 31.2 years participated in Experiment I.

Experiment II: Forty-eight licensed drivers were selected on the basis of their familiarity with the routes of travel designated in the questionnaire. We were interested in any possible differences in response to advisories based on gender and age, so we selected drivers in two age groups; younger than fifty-five years of age and fifty-five or older. Mean age for younger participants was 31.6 years and for older participants 66.2 years. There were twelve females and twelve males in each age group.

Questionnaire Components

Routes

The questionnaire stated the main route taken between an origin and destination, as well as one alternate route. The purpose of the route specification was to ensure all participants considered the same options and to diminish biases toward favorite routes or short-cuts. Main routes were always interstate freeways. Alternate routes were highways or major metropolitan thoroughfares. Along the main route there was a minimum of three connecting roads to the alternate route. These roads served as exiting options between a participant's current location and the planned exit.

Experiment I: Participant's origin was home. Destination was a parking ramp on the University of Minnesota East Bank Campus. There were four possible routes between home and the ramp based on the four cardinal directions. Participants were assigned to a route based on the direction they routinely traveled to campus. For persons traveling from the north the main route was I-35W with Central Avenue (Hwy. 52) as an alternate. The main route for westbound participants was I-94 and the alternate was University Avenue (Hwy. 47). For participants who normally travel to campus from the south the main and alternate routes were I-35W and Portland/Park Avenues respectively. The main and alternate routes for eastbound participants were I-394 and Highway 55, respectively.

Experiment II: Participant's origin was downtown Minneapolis. Destination was the Twin Cities International Airport. There was only one specified main and alternate route between downtown and the airport. The main route was southbound I-35W to eastbound I-494 to the airport exit. Cedar Avenue (Hwy. 77) southbound to I-494 was the alternate.

Scenarios

The questionnaires for both experiments contained descriptions of traffic settings in the form of scenarios. Each scenario described a set of circumstances which served as a background for the presentation of advice. The purpose of the scenarios was to provide a common background among the participants so that the responses to the advisory messages reflected the message and not unknown factors. The scenarios provided the same sort of information a participant would be expected to have in the real world of driving. Each scenario contained information which was consistent among scenarios and information that was varied among scenarios. The information which was varied represented the main variables of the experiment.

Experiment I: There were four scenarios created for the pilot study. Table 1 illustrates the information which remained constant among the four scenarios. Three aspects of the scenarios were varied; (1) Past Information, (2) Alternate Information and (3) Traffic Flow. Past information refers to the accuracy of traffic information reports previously received. There were three levels for this variable; (i) some belief in accuracy of messages, (ii) past messages had been correct and (iii) past messages had been incorrect. The second variable of interest was whether traffic information was available on the alternate route. The two levels for this variable included (i) no information available and (ii) information available-alternate not congested. Finally, the observed traffic levels on the main route were varied between (i) uncongested and (ii) congested. Differences between the scenarios are listed below.

(Please note: The wording has been generalized to conform to any direction of travel. That is, instead of stating each of the various main and alternate routes used for the different versions of the Experiment I questionnaire the phrases, [main route] and [alternate route], have been substituted and placed in brackets.)

Scenario 1

There is no congestion evident on [main route] and the participant has no information about traffic on [alternate route]. Participants have some belief about the accuracy and timeliness of advisory messages.

Scenario 2

There is congestion evident on [main route] and the participant has been told that [alternate route] is not congested. Participants have some belief about the accuracy and timeliness of advisory messages.

Scenario 3.

There is congestion evident on [main route] and the participant has been told that [alternate route] is not congested. In similar past circumstances participants had been correctly told that alternates were not congested.

Scenario 4.

There is congestion evident on [main route] and the participant has been told that [alternate route] is not congested. In similar past circumstances participants had been incorrectly told that alternates were not congested.

Table 1
Scenario Similarities

Information	Experiment I Detail	Experiment II Detail
ORIGIN & DESTINATION	Home to East Bank Parking Ramp	Downtown to Airport
TIME OF DAY & DAY OF WEEK	8:00 am on an Ordinary Workday	8:00 am on an Ordinary Workday
MAIN & ALTERNATE ROUTES	See ***Routes*** Section Above	See ***Routes*** Section Above
ROUTE TRAVEL TIMES	Main: 20 Minutes Alternate: 25 Minutes	Main: 25 Minutes Alternate: 40 Minutes
PURPOSE OF TRAVEL	To Attend a Meeting	To Catch a Departing Flight
TIME CONSTRAINT	30 Minutes (Meeting at 8:30 am)	1 Hour (Flight Leaves at 9:00 am)
WEATHER CONDITIONS	Light Snow Fall	Not Specified

Experiment II: There were four scenarios created for the primary study. Table 1 illustrates the information which remained constant between the scenarios. Two aspects of the scenarios were varied; (1) Past Information and (2) Traffic Flow. Past information refers to the accuracy of traffic information reports previously received. There were two levels for this variable; (i) past messages had been accurate or (ii) past messages had been inaccurate. Secondly, the observed traffic levels on the main route were varied between (i) heavy congestion and (ii) light congestion. Differences between the scenarios are listed below.

Scenario A

This scenario presented the participant with light and smooth flowing traffic on the main route, and a history of inaccurate information from advisories.

Scenario B

This scenario presented the participant with light and smooth flowing traffic on the main route, and a history of accurate information from advisories.

Scenario C.

This scenario presented the participant with heavy, congested traffic on the main route, and a history of accurate information from advisories.

Scenario D.

This scenario presented the participant with heavy, congested traffic on the main route, and a history of inaccurate information from advisories.

Advisory Messages

The structure of advisory messages was varied on three aspects in both Experiments I and II; (1) options, (2) imperativeness and (3) quantitativeness. There were two levels for each variable. Options referred to the amount of time remaining to the drivers to decide whether to change their travel plan based on the received traffic information or whether to ignore the information. This amount of time was reflected in the number of exit options remaining prior to the planned exit. Traffic information presented to participants with three exits of interest between their current position and the planned exit was considered "many" options. The many options condition was assumed to allow respondents a greater lead time for making up their minds about route alternatives. At the other extreme, information presented to participants with only one exit between their current position and the planned exit was considered "few" options. Few options was assumed to require a decision about exiting to be made in only a few seconds.

Imperativeness referred to whether participants were given a directive to take some action. Advisory messages either contained a directive to depart from the main route or they did not. Messages stating "Congestion" were considered nonimperative, while messages such as, "Exit and Follow Cedar Avenue to I-494", were considered imperative.

Quantitativeness referred to numerical information embedded in the message. Traffic information stating, "10 Minute Delay", was considered quantitative. A message simply stating, "Delays", was not quantitative. Advisory messages either contained numerical information about an incident or they did not.

Experiment I: Table 2 lists all eight advisory messages used for the pilot study. To the right of each message is listed the level of each independent variable.

(Please note: Some of the wording used below is specific to only one of the four directions of travel used in the Experiment I questionnaire. These words have been placed in brackets.)

Table 2
Advisory Messages - Experiment I

No.	Message	Options	Imperative	Quantitative
1	Congestion Ahead.	Many	No	No
2	Congestion Ahead.	Few	No	No
3	Delays Ahead. Some Exits [West] of the Mississippi Are Closed.	Many	No	No
4	Delays Ahead. Some Exits [West] of the Mississippi Are Closed. Exit at [Highway 100].	Few	Yes	No
5	Delays Ahead. Some Exits [West] of the Mississippi May Be Closed.	Few	No	No
6	5 Minute Delays Ahead. U of M East Bank Exit is Closed.	Many	No	Yes
7	5 Minute Delays Ahead. U of M Exit is Closed. Exit at [Penn Avenue] and Use [Highway 55] as an Alternate.	Many	Yes	Yes
8	Congestion Ahead. Ramp Closings. 5 Minute Delays. Use [Penn Avenue] Exit and [Highway 55] Alternate.	Few	Yes	Yes

Experiment II: Table 3 lists all eight advisory messages used for the primary study. To the right of each message is listed the level of each independent variable.

Table 3
Advisory Messages - Experiment II

No.	Message	Options	Imperative	Quantitative
1	Congestion. 10 Minute Delay. Exit and Follow Cedar Avenue to I-494.	Many	Yes	Yes
2	Congestion. Delays. Exit and Follow Cedar Avenue to I-494.	Many	Yes	No
3	Congestion. Delays.	Many	No	No
4	Congestion. 10 Minute Delay.	Many	No	Yes
5	Congestion. 10 Minute Delay. Exit and Follow Cedar Avenue to I-494.	Few	Yes	Yes
6	Congestion. Delays. Exit and Follow Cedar Avenue to I-494.	Few	Yes	No
7	Congestion. Delays.	Few	No	No
8	Congestion. 10 Minute Delay.	Few	No	Yes

Choices

After presentation of an advisory message participants were given response choices. These choices represented options which would be available to a person actually driving under the conditions of the experiment. Participants were instructed to respond to the choices based only on the experiences described by the questionnaire, not on any actual personal experiences on the road segment described. Only one choice was allowed.

Experiment I: Participants in the pilot study had a list of several choices from which to choose. The first was always "ignored the message...". The middle options were indications that they planned to divert from the main route prior to the planned exit. A choice of this nature was listed for each of the available exit options (designating remaining connecting roads between the main and alternate routes). The final choice was always to bypass the planned exit for the next available exit. Examples of each of these choices are listed below.

1. Ignored the message and continued on [main route] hoping that the U of M East Bank Exit was still open.
2. Planned to exit at [exit option] if it was still open and then use [alternate route].

3. Planned to cross the Mississippi on I-94 , take the first exit and get to the parking ramp via Washington Avenue thus avoiding [alternate route] traffic.

Experiment II: Participants in the primary study had only two choices from which to select. Again selection of only one choice was allowed. The choices are listed below.

1. Ignore the advisory and continue along I-35W to your planned exit, I-494.
2. Change your original plan and decide to divert from I-35W prior to I-494 to follow the Cedar Avenue alternate route.

Reasons

After selecting a choice participants were asked to give a reason as to why that particular choice was made. Unlike the selection of choices, participants were asked to select reasons based on actual past personal experiences with traffic messages. Reasons were selected from a list and more than one selection was allowed.

Experiment I: For the pilot study there was a separate list of reasons for each available choice. All reasons were on a preprinted listing. Only reasons from this list were accepted. A few examples of reason offerings are listed below.

1. Such messages are usually incorrect or exaggerated.
2. You did not know what the message meant.
3. Your past general experience on various highways in acting on similar messages has usually led to long delays.
4. Your past experience with this or similar messages has caused you long delays when you took the parallel street option (consider any options you may have taken in the past, not just [alternate route]).
5. Your past experience with traveling to work on [alternate route], when there has been a problem on [main route], is one of long delays.
6. You believed that the snow would not hamper traffic as much on [main route] as it would on the alternate routes.

Experiment II: For the primary study there was a single list of reasons for all available choices. A preprinted listing of nine reasons was supplied to the participant. However, there were also spaces for participants to write-in up to two additional reasons not present on the list. The following is a list of the reasons offered to participants.

1. The intent of the message was not clearly stated;
2. It was a coin toss, you did not know which option would be better;
3. The consequences of being late for your flight were too terrible to ignore;
4. You felt you could make it to an exit closer to the airport (if not the airport itself) before the delays on the main route began;
5. Your past actual experience on various highways in acting on similar messages has usually led to long delays for you;
6. You would rather gamble on the main route than risk delays on the alternate because too many drivers may switch to the alternate route;
7. You would rather take your chances on the main route than become lost on the alternate;
8. Your past actual experience with similar messages has led you to conclude that traffic advisories almost always can be trusted and should be followed;
9. Your past actual experience has led you to conclude that traffic advisories cannot be trusted. But, you took the alternate route anyway since you could not afford to take the chance that the main route would be at a standstill before you reached the airport;
10. Write in other: ____
11. Write in other: ____

General Information Survey

The general information survey has traditionally been administered to all HFRL participants taking part in experiments focusing on driving behavior. It is used to solicit data on age, vision, driving history, patterns and frequency. In addition to this general information we included a series of scaling questions designed to measure participant biases toward punctuality and advisory messages.

Experiment I: For the pilot study we elicited responses to two scaling questions. The first was in relation to punctuality and the second to strength of belief in advisory messages. The strength of a respondent's belief was based on their past actual driving experience. Each of these questions is presented below along with the associated Figure which lists the scale's peg points.

> *Punctuality*: On the following motivation scale please rate yourself on the usual strength of your intent or motivation to reach your workplace on time. Circle only one choice. For the list of choices see Figure 1.
>
> *Belief in Advisories*: On the following scale please rate the strength of your belief, based on your past actual experience, in the timeliness and accuracy of information contained in traffic advisories. Circle only one choice. For the list of choices see Figure 2.

Experiment II: For the primary study we elicited responses to three scaling questions. The first two, dealing with punctuality and belief in advisory messages, were identical to those described under Experiment I above. The third addressed belief in advisories when there is no visual reinforcement for an advised incident. The third question is listed below along with the associated Figure which lists the scale's peg points..

> *Belief in Advisories Which Suggest Congestion*: Based on your belief in advisories, as indicated in question 20, how strong is your desire to leave your planned route for an alternate route, when you are warned of heavy congestion in an advisory yet the level of congestion actually seen on the roadway is minimal. Circle only one choice. For the list of choices see Figure 8.

Experimental Design

Experiment I: Six independent variables were manipulated; three in relation to the scenarios ("past information", "alternate information" and "traffic flow") and three in relation to the advisory messages ("options", "imperativeness" and "quantitativeness"), as described in the "Scenarios" and "Advisory Messages" sections above. A within-subjects, partial factorial design was developed yielding 32 conditions. (Five of the six independent variables had two levels and one had three levels. Thus, a complete factorial design would yield 96 conditions, 2x2x2x2x2x3=96. This is a partial factorial design because only 32 of the 96 conditions were selected.) Two counterbalanced orders were used for presentation of the conditions; half the participants received one order, half received the other.

Two dependent variables were recorded; (1) the choice response and (2) the reason for the response. Data was tabulated and analyzed using descriptive statistics.

Experiment II: Five independent variables were manipulated; two in relation to the scenarios ("past information" and "traffic flow") and three in relation to the advisory messages ("options", "imperativeness" and "quantitativeness"), as described in the "Scenarios" and "Advisory Messages" sections above. In addition, there were two categorical variables. The first, age, had two levels (i) young and (ii) old. The second categorical variable was gender, also with two levels, (i) female and (ii) male. Thus, a mixed between/within subjects, complete factorial design was used with two levels of both between subjects variables (i.e., categorical variables) and two levels of each of five within subjects variables (i.e., independent variables). This arrangement yields 32 (2x2x2x2x2) conditions completed by four (2x2) groups of subjects. Twelve counterbalanced presentation orders were created for the conditions. The same twelve orders were used for all four participant groups. Each group contained twelve members, thus, each individual within a group received a different presentation order.

Two dependent variables were recorded; (1) the choice response and (2) the reason response. Data was tabulated and analyzed using a Multivariate Analysis Of Variance (MANOVA) and descriptive statistics.

RESULTS

Experiment I

Choice Main Effects

Effect of Scenarios on Choice Responses: Table 4 shows the effect of scenarios on the choices selected by the participants. Data represent percent respondents selecting a particular choice. The factors of interest are the message statements regarding congestion on main and alternate routes and whether previous advisories had been correct or incorrect.

Table 4
Effect of Scenario Structure on Choice Responses - Experiment I

Scenario	Ignored Message	Exited Early	Exited Late
Main route uncongested; No information about alternate route; No information about past advisory accuracy.	29 %	34 %	18 %
Main route congested; Alternate route not congested; No information about past advisory accuracy	22 %	39 %	9 %
Main route congested; Alternate route not congested; Past advisories accurate.	17 %	41 %	9 %
Main route congested; Alternate not congested; Past advisories inaccurate.	23 %	38 %	14 %

In the second column (ignored message) we see that when incremental amounts of information about the alternate routes were added (from none, to alternate not congested, to alternate not congested and correct information given in the past) the percentage of respondents selecting "ignored message" decreased. Furthermore, when participants were incorrectly told about traffic conditions in the past, the percentage of participants selecting "ignored message" was greater when compared to participants who had received correct information in the past (Scenario 3 vs. Scenario 4).

Effect of Advisory Messages on Choice Responses: In Table 5 the number of people responding to each of the choices for each of the advisories was tabulated. The numbers in the table represent mean percent respondents selecting a particular choice, collapsed across directions and scenarios. (For reference purposes a summary of advisories can be found in Table 2.) Advisories with an "I" designator indicate the message contained imperative information. A "Q" designator indicates the message contained quantitative information. An "IQ" designator indicates the message contained both imperative and quantitative information. A cell containing "na" means that choice was not an available selection for the associated advisory.

Table 5

Effect of Message Structure on Choice Responses - Experiment I

	Choice			
Advisory	**Ignored Message**	**Exited at First Early Opportunity**	**Exited at Second Early Opportunity**	**Exited Late**
1	38%	39%	23%	na
2	52%	48%	na	na
3	24%	41%	24%	11%
4^{I}	14%	74%	13%	na
5	30%	50%	20%	na
6^{Q}	3%	39%	40%	18%
7^{IQ}	4%	56%	32%	9%
8^{IQ}	17%	75%	8%	na

Following each advisory, one of the selections a participant might make was to ignore the message and to continue as planned. This choice is represented by the second column in the table above. All other choices required the participants to alter their original plans. These altered plans required exiting at some ramp either prior to or after the planned exit.

A significant finding of this project can be seen by observing the mean percentages for "ignored message" vs. the mean of all other choices. For example, near the top of the table we see that the mean percentages for Advisory 1 are 38%, 39% and 23%. We can compare "ignored message", which is 38%, with the mean of the other two choices, which is 31% (the sum of 39%

+ 23% divided by 2). If we repeat this analysis for all advisories we have the data shown in Table 6. We can see from this table that for the four advisories which are either quantitative, imperative or both, very few participants selected "ignored message" while for advisories which were neither quantitative nor imperative, the percentage of respondents selecting "ignored message" was almost equal to the percentage selecting the other choices. This is the major finding of the pilot study.

Table 6
Comparison of "Ignored" Choice with All Other Choices - Experiment I

Advisory	Ignored Message	Other
1	38 %	31 %
2	52 %	48 %
3	24 %	25 %
4^{I}	14 %	44 %
5	30 %	35 %
6^{Q}	3 %	32 %
7^{IQ}	4 %	32 %
8^{IQ}	17 %	41 %

Reason Main Effects

Table 7 shows the reasons selected by participants who made the choice "Ignored Message". The data in the table represent percent responses. The percentages were obtained by adding across scenarios the number of responses (from the 64 participants) indicating the reason, "Such messages are usually incorrect or exaggerated," the number indicating "You did not know what the message meant," the number of responses indicating any of the three reasons related to negative past actual experience due to acting on advisory messages, and the number indicating a reason other than one of these three categories. The "other " category includes reasons indicating either weather or pure chance were factors influencing participants' decisions.

There are two findings of note. First, many of the responses indicated a failure to understand the message, even messages as seemingly simple as "Congestion Ahead". Second, with the exception of Advisory 6, the percentages for each reason remain relatively stable across advisories. In other words, the reasons selected do not seem dependent on advisory structure. Responses given for Advisory 6, however, indicate that the presence of quantitative information reduces the vagueness of a message and is strongly associated with incorrect or poorly timed information.

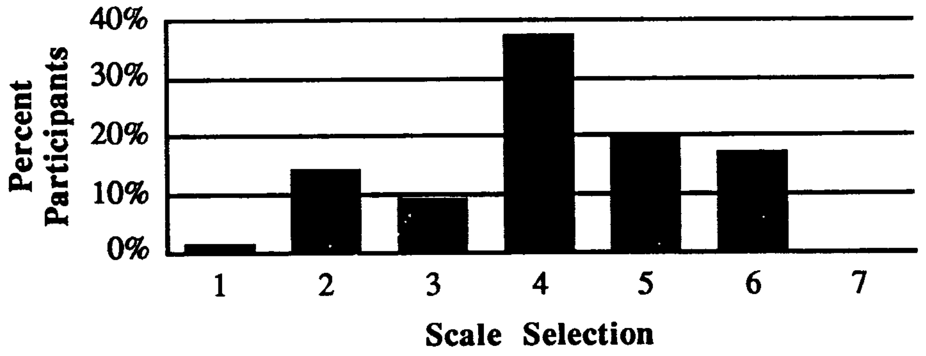
Table 7
Reasons for Selecting "Ignored Message" - Experiment I

Advisory	Reason			
	Message Wrong or Exaggerated	Didn't Understand Message	Past Negative Experience	Other
1	27%	19%	40%	14%
2	23%	13%	45%	19%
3	24%	15%	45%	16%
4^{I}	25%	18%	44%	13%
5	17%	15%	37%	30%
6^{Q}	88%	0%	0%	13%
7^{IQ}	21%	14%	45%	21%
8^{IQ}	18%	14%	67%	0%

Scaling Questions

Punctuality: The results of the scaling question designed to measure the strength of participants' desire to be punctual are shown in Figure 1. The data are percentages representing the number of participants selecting a particular response.

The chart shows a slight skewing to the right as evidenced by 75% of the population giving responses 4, 5, or 6. The data shows that our sample is not extreme in its desire to be punctual but that this population would clearly prefer to be on time rather than to be late.

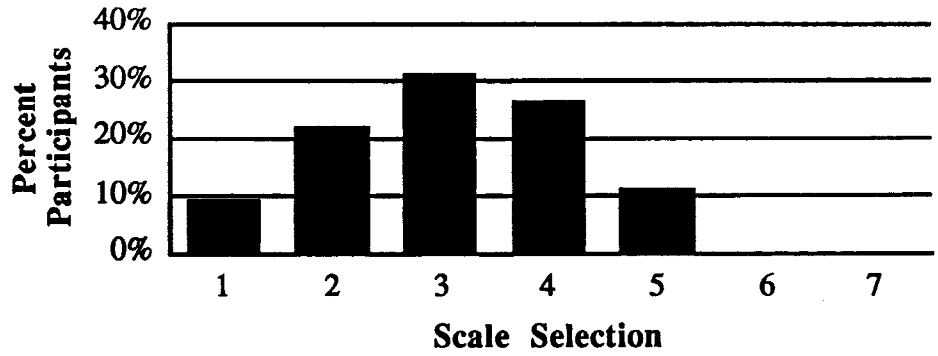


1) I do not mind being late, punctuality has never meant much to me.
2) I'd like to be on time but "better late than never" has always been my motto.
3) I don't not mind being a little late, almost everyone else is usually late.
4) I prefer to be on time.
5) I try hard to be on time and I am embarrassed when I am late.
6) I am a very punctual person and I take great pains to be on time.
7) I would risk anything to avoid being even a minute late.

Figure 1
Punctuality Scale - Experiment I

Belief in Advisories: Figure 2 summarizes participant responses to a scaling question rating beliefs in the accuracy and timeliness of advisories based on actual past experiences. The data represent percentage of participants selecting a particular response.

This distribution is nearly normal but skewed to the left. That is, no respondents were extremely negative in their views about the accuracy and timeliness of traffic advisories. The modal response was "I know there may be mistakes in information and delays in getting it to me, but I often follow the advice anyway."



1) I implicitly trust the accuracy of the information and believe that it is given early enough to allow me plenty of time to act in following the advice.
2) There may be occasional errors and delays in getting information to me but I usually follow the advice.
3) I know there may be mistakes in the information and delays in getting it to me, but I often follow the advice anyway.
4) The information usually somewhat overstates the severity of the problem and occasionally the information is somewhat tardy so that situations have actually improved so that I may or may not follow the advice.
5) The information and its timeliness is better than nothing and I may even follow it if I feel like it.
6) The information's accuracy is no better than a coin toss and its timeliness is no better. Whether or not I act on the advice is also a coin toss.
7) The information is seldom correct and even if it is partly correct, it is given so late that the situation reported no longer obtains. I seldom pay serious attention to the advice and rarely take it.

Figure 2
Belief in Advisories Scale - Experiment I

Experiment II

Choice Main Effects

Effect of Scenarios on Choice Responses: The main factors of interest for the scenarios were; (1) observed traffic flow and (2) the accuracy of past information. Results from a repeated measures Multivariate Analysis of Variance (MANOVA) indicated that both traffic flow ($F[1, 44] = 37.916$, $p < .001$) and past information ($F[1, 44] = 14.571$, $p < .001$) were significant. (A $p < .001$ implies there is a probability of 1/1000 that chance alone could account for differences as large as those observed.) In general, participants given a history of accurate information, were more likely to indicate early departure than if they had been given inaccurate information. Additionally, visible levels of heavy traffic were much more likely to induce departure from the main route than was the absence of any visible congestion. The mean percent participants who indicated diversion based on scenarios are illustrated in Figure 3.

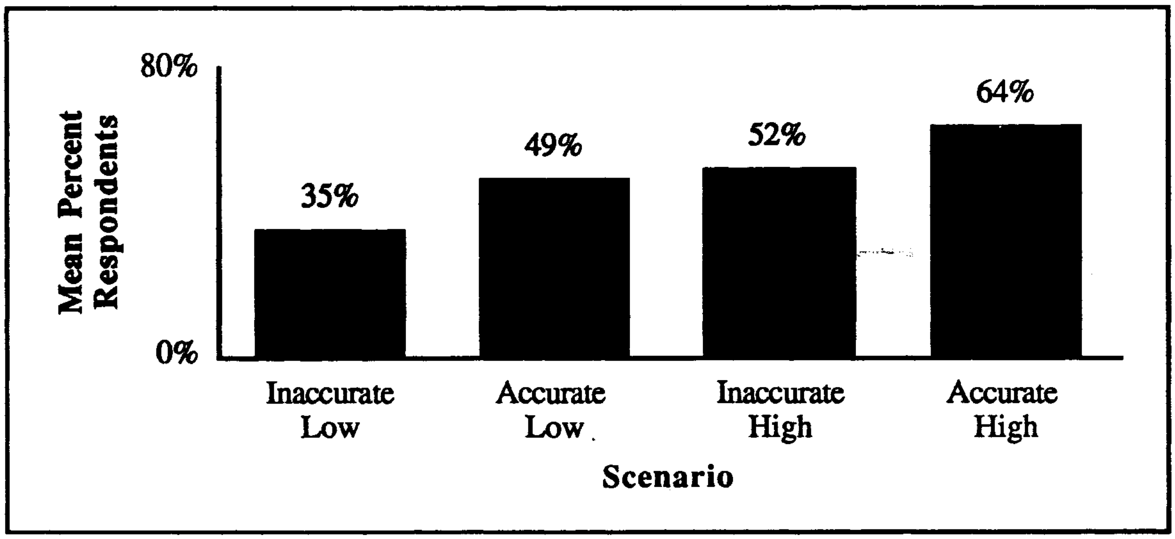


Figure 3
Mean Percent Participants Who Indicated Departure From The Planned Route By Scenario - Experiment II

Effect of Advisory Messages on Choice Responses: The structure of each advisory was based on three factors: (1) the number of options, (2) the imperativeness of the advisory and (3) the quantitativeness of the advisory. Results from a repeated measures MANOVA are as follows: Options ($F[1, 44] = 6.133$, $p < .05$) and imperativeness ($F[1, 44] = 12.541$, $p < .01$) were found to be significant. Quantitativeness was not statistically significant. In terms of options, the propensity to depart from the planned route was greater when the participants had fewer options than when they had many options. Furthermore, analysis indicated that the presence of imperative information affected a route change more so than the lack of imperative information. However, contrary to expectation, the mean number of participants who indicated diversion based on receipt of quantitative information was slightly smaller than the number who indicated diversion without receipt such information. However, it was clear that adding numerical information to the messages did not detract from the impact of the advisory. The mean percent participants who indicated diversion based on advisories are illustrated in Figure 4.

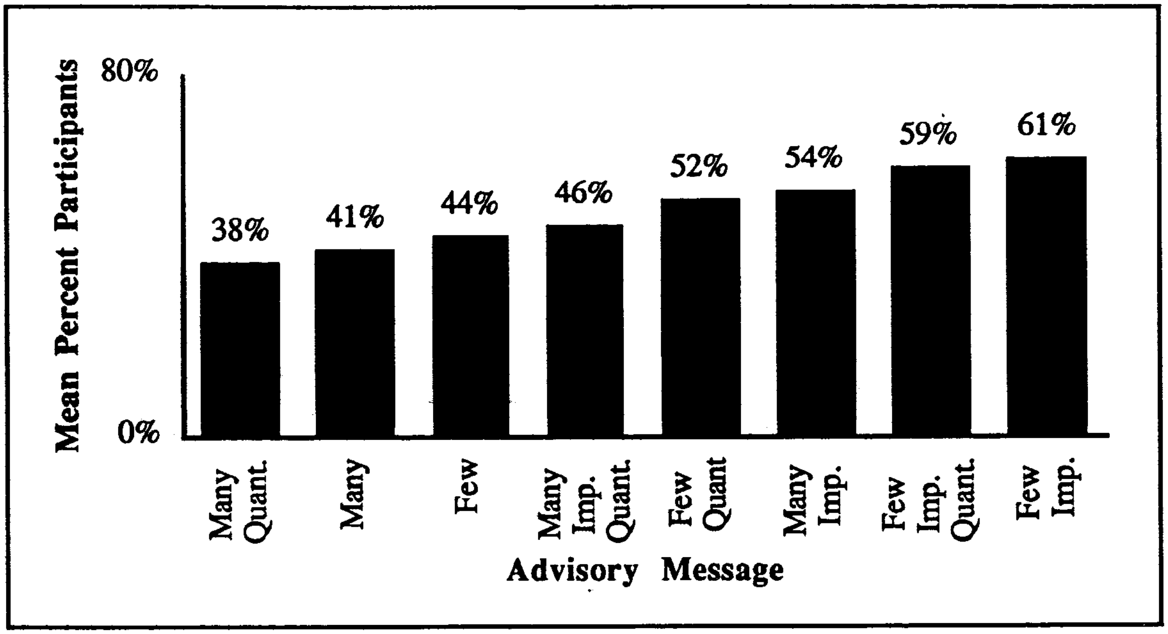


Figure 4
Mean Percent Participants Who Indicated Departure From The Planned Route By Advisory - Experiment II

Effect of Gender and Age on Choice Responses: In relation to gender and age differences a MANOVA indicated no statistical significance. Figure 5 illustrates the mean percent responses indicating departure from the planned route by age and gender.

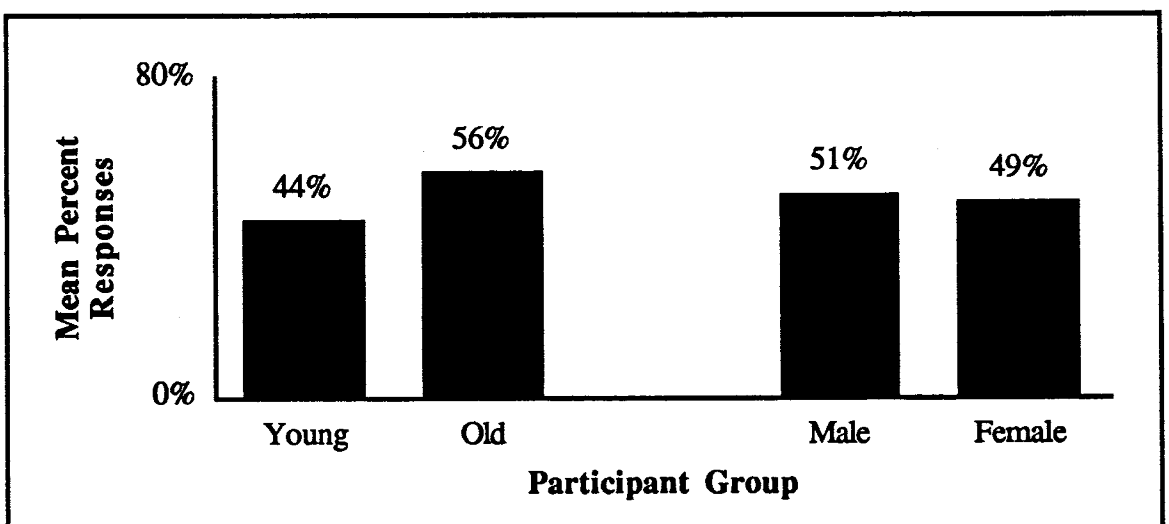


Figure 5
Mean Percent Responses Indicating Departure From The Planned Route By Age and Gender - Experiment II

Reason Main Effects

In Experiment II participants were given two options upon receipt of an advisory message; either ignore the message or take action on the information and change the original plan of travel. The reasons given by participants for selecting the choice, "change original plan...", have been tabulated by advisory and are presented in Table 8. Refer to the ***Reasons*** paragraph in the METHODS section above for a list of reasons 1 through 9. The two most popular reasons written in by participants for changing the alternate route are as follows: First, participants were familiar with the trouble spots along the main route and means for reducing trip times by using the alternate route. Second, participants had a strong desire to avoid long delays when heavy traffic was visible on the main route. Of the fifteen participants who wrote their own reasons on the answer sheet for changing their original travel plan, these two reasons account for eleven of the responses.

Three important points can be observed from the table. First, the percentages for each reason remain relatively stable across advisories. In other words, the reasons selected do not seem dependent on advisory structure. Second, two reasons are consistently cited more frequently than the others, number 3 and number 8. The third reason refers to the negative consequences of arriving at the destination late and the eighth reason refers to a positive history of accurate and timely advisory messages. Finally, it is interesting to note the pattern of responses for reason 1, "the intent of the message was not clearly stated". For this reason the frequency of responses is extremely low when both imperative and quantitative information were present in a message (advisories 1 and 5) and substantially higher when the message lacked either form of information (advisories 3 and 7).

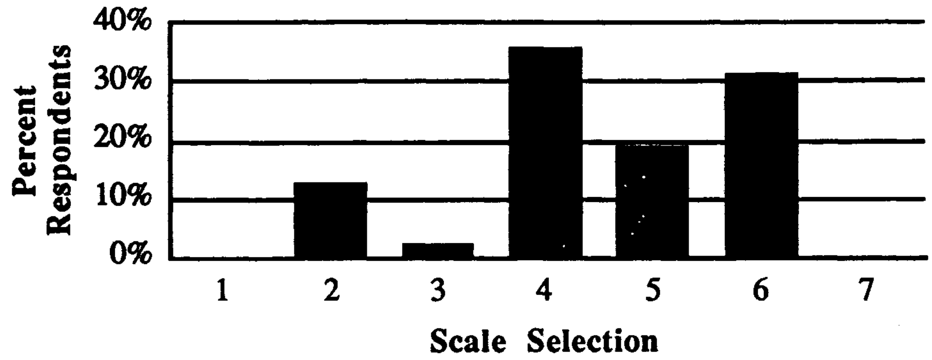
Table 8
Reasons For Selecting "Changed Original Plan" - Experiment II

	Advisory							
Reason	1^{IQ}	2^{I}	3	4^{Q}	5^{IQ}	6^{I}	7	8^{Q}
1	1 %	4 %	10 %	3 %	1 %	3 %	9 %	3 %
2	12 %	8 %	8 %	11 %	11 %	11 %	12 %	14 %
3	22 %	23 %	24 %	17 %	25 %	24 %	22 %	23 %
4	10 %	10 %	11 %	16 %	5 %	5 %	6 %	9 %
5	8 %	6 %	4 %	8 %	4 %	7 %	5 %	2 %
6	1 %	2 %	1 %	0 %	0 %	1 %	1 %	2 %
7	0 %	2 %	1 %	0 %	0 %	0 %	1 %	1 %
8	23 %	27 %	17 %	20 %	26 %	27 %	21 %	18 %
9	13 %	11 %	11 %	13 %	15 %	9 %	8 %	14 %
10	6 %	5 %	7 %	9 %	9 %	8 %	11 %	9 %
11	3 %	3 %	5 %	3 %	3 %	4 %	5 %	5 %

Scaling Questions

For Experiment I we showed the results of scaling attitudes about punctuality and belief in the accuracy of advisories (Figures 1 and 2). In Experiment II we repeated this procedure and the results are shown in Figures 6 and 7. A third scale was added as part of Experiment II. These results are shown in Figure 8.

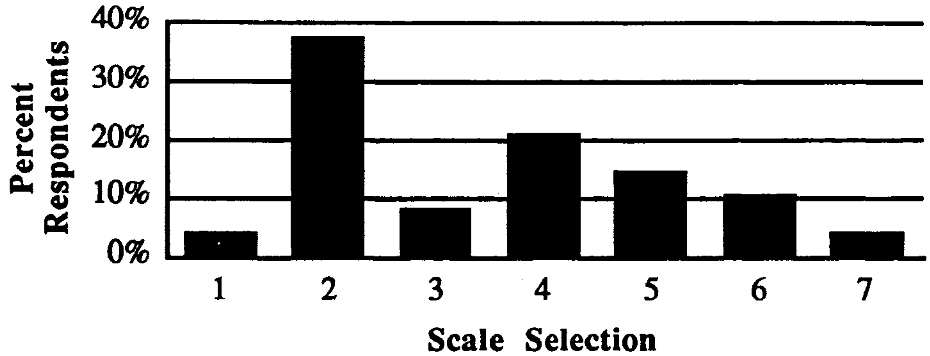
Punctuality: The punctuality scale in Figure 6 illustrates a skewing to the right, similar to that of Figure 1. This trend is indicated by 85% of the sample giving responses that fall between "prefer to be on time" and "take great pains to be on time." Clearly punctuality was a motivating factor for this population.



1) I do not mind being late, punctuality has never meant much to me.
2) I'd like to be on time but "better late than never" has always been my motto.
3) I don't not mind being a little late, almost everyone else is usually late.
4) I prefer to be on time.
5) I try hard to be on time and I am embarrassed when I am late.
6) I am a very punctual person and I take great pains to be on time.
7) I would risk anything to avoid being even a minute late.

Figure 6
Punctuality Scale - Experiment II

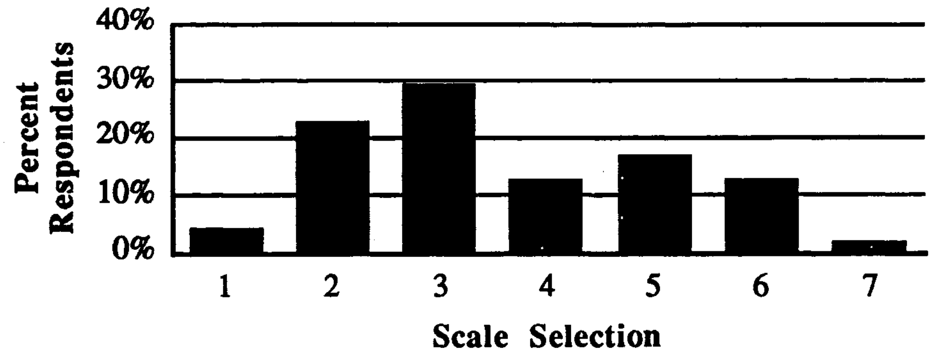
Belief in Advisories: The data in Figure 7 illustrate a bias to the left, similar to Figure 2. It can be seen that of the 48 respondents, 50% indicated a strong belief in advisories, 36% somewhat trusted advisories and only 14% distrusted advisories. This represented a population which was highly skewed toward trust in the advisory messages they had seen in the past.



1) I implicitly trust the accuracy of the information and believe that it is given early enough to allow me plenty of time to act in following the advice.
2) There may be occasional errors and delays in getting information to me but I usually follow the advice.
3) I know there may be mistakes in the information and delays in getting it to me, but I often follow the advice anyway.
4) The information usually somewhat overstates the severity of the problem and occasionally the information is somewhat tardy so that situations have actually improved so that I may or may not follow the advice.
5) The information and its timeliness is better than nothing and I may even follow it if I feel like it.
6) The information's accuracy is no better than a coin toss and its timeliness is no better. Whether or not I act on the advice is also a coin toss.
7) The information is seldom correct and even if it is partly correct, it is given so late that the situation reported no longer obtains. I seldom pay serious attention to the advice and rarely take it.

Figure 7
Belief In Advisories Scale - Experiment II

Belief in Advisories Which Suggest Congestion: The results from the third scaling question are illustrated in Figure 8. This question differed from the previous one in that it queried participants on their motivation to depart from a planned route without visual reinforcement of an incident after being warned of congestion. The sample appears nearly normal in distribution with 56% of the sample indicating a high motivation to depart without visual confirmation and 45% with a moderate to low motivation to depart without visual evidence of congestion.



1. I implicitly trust the accuracy of the information and believe that the amount of congestion indicated in the advisory is immediately imminent. Thus, my desire to exit at the next opportunity would be very strong.
2. There may be occasional errors and delays in getting information to me. However, I suspect that congestion will build quickly so my desire to exit soon is high.
3. I know there may be mistakes in the information and delays in getting it to me. I anticipate that congestion levels will build in the near future so I have a moderate desire to exit relatively soon.
4. The information usually somewhat overstates the severity of the problem and occasionally the information is somewhat tardy. Thus my desire to exit is moderate and I will only do so after I see traffic beginning to slow down significantly.
5. The information and its timeliness is better than nothing. I anticipate congestion levels will build slowly. My desire to exit is moderate and I will wait for traffic to become heavily congested before I decide to exit early.
6. The information's accuracy and its timeliness is no better than a coin toss. My desire to exit is low. I will wait to see if traffic comes to a standstill before deciding to exit early.
7. The information is seldom correct and even if it is partly correct, it is given so late that the situation reported no longer exists. My desire to exit is very low.

Figure 8
Belief in Advisories Which Suggest Congestion Scale - Experiment II

DISCUSSION

Summary of Findings

The primary findings from this research were that both the structure of traffic information messages and the accuracy of information received in the past affect participant responses to such information. The presence of quantitative and/or imperative information within a traffic message encouraged participants to alter their original plans by indicating they would depart from the planned route ahead of schedule. In addition, a history of accurate traffic information was more likely than a history of inaccurate information to encourage early departure from the planned route.

Both Experiments I and II supported these findings, confirming the hypothesis on which the study was based. That is, the structure of a traffic message influences the subsequent behavior of the driver. Furthermore, behavior is altered in the direction which would tend to reduce congestion and enable reasonable options for traffic managers. Thus, traffic managers could act to further reduce congestion with the tools now available to them.

Message Structure

Information Accuracy

Experiment I suggested and Experiment II confirmed that the accuracy of traffic information received in the past was related to driver behavior for subsequent advisory messages. Results demonstrated that participants who had received accurate past information were more likely, than participants who had received inaccurate past information, to act on current information without waiting for visual evidence of congestion. That is, participants who had received a history of accurate traffic messages demonstrated a higher level of trust in advisory messages. Figure 3 shows nearly 50% of the participants, when given accurate past information, indicated they would depart the planned route early before traffic levels became heavy, compared with 35% when given an inaccurate history. This 50% is equivalent to the 50% in Figure 7 who indicated a relatively strong belief in advisory messages and quite close to the 56% in Figure 8 who indicated strong motivation to depart without visual confirmation of congestion.

Quantitative Message Content

Both Experiments I and II demonstrated a relationship between message structure and participants' indicated departure from the planned route. A positive relationship between imperativeness and early departure was established by both the primary and pilot studies, however, only the pilot study demonstrated a similar relationship for quantitative message content (the primary study found no statistical significance for quantitativeness). This phenomenon goes against our expectation that the presence of quantitative information (as well as imperative or both) would substantially influence participant behavior in a direction that would reduce congestion. We believe this phenomenon may be explained by comparing scenario details to message details. The scenarios in Experiment II stated the alternate route would add 15 minutes to total travel time. The advisory messages in Experiment II stated a 10 minute delay. Hence, it was more attractive to remain on the congested main route than divert to the alternate route. Had the alternate been neutral or more attractive, in terms of time conservation, we believe a significant effect would have been found in Experiment II for quantitativeness. This was in fact the case for the pilot study (see Figure 6) which did not directly present a time advantage for selecting a particular route. Scenarios in Experiment I stated that diverting to the alternate route would add 5 minutes to total travel time. Advisory messages in Experiment I stated 5 minute delays. In addition, for Experiment II the most popular write-in reason given for ignoring the message was that the delay on the main route was shorter than the one which would have been incurred by diverting to the alternate route.

We believe the inadvertent benefit given to selection of the main route in Experiment II explains two unexpected results. First, no significant effect was found for quantitative message content. Second, the advisory message with quantitative information and many options was the least effective message of the eight in prompting a route change (see Figure 4). The mean percent participants who indicated departure for quantitative and nonquantitative messages was 49% and 51% respectively. The difference between the two is practically negligible. It seems apparent then that when minor delays (in relation to a participant's alternatives) were to be encountered, presenting quantitative information was no more effective than the lack of such information in encouraging departure from the planned route. This was especially true when the participant had a substantial amount of time (in terms of exit options) remaining prior to arrival at the planned exit. When the number of opportunities to exit was high, fewer participants indicated departure based on receipt of quantitative information. In fact, the number indicating departure was even less than when no numerical information had been given. This may be due to the fact that when many exit opportunities are present the risks for remaining on the planned route are lower. The risk is lower because there remain ways to avoid any congestion which may be encountered. This however, is not the case when there is only one opportunity to exit. If the opportunity to exit is not taken the risk of becoming delayed is higher. It was under this condition that the presence of quantitative information was most effective in encouraging departure from the main route.

Current Message Characteristics

Several national and international organizations have prepared lists of traffic messages. These lists have, as far as we know, not considered effects on drivers' behavior with regard to message structure. If there has been a guiding principle in the preparation of these lists, it would appear to be terseness. Terse messages lend themselves to the "Chinese menu" mode of construction. This is convenient for both the messages which are broadcast to in-car radios and to the Radio Data Systems (RDS) which display messages on such radios. Terse messages are also convenient for external vehicle displays such as CMS and VMS. This is particularly true for signs with fixed messages imprinted on turnable cylinders where each cylinder forms one line of the message. Under these types of applications, RDS and CMS/VMS, message length plays a critical role. The shorter the message, the less time drivers need to be distracted from driving, either while scrolling the display to see longer messages or reading messages alongside or over the road.

Based on the data presented in this study, we can conclude that terseness is not the only factor which should be considered in the preparation of traffic messages. Even if there was a greater cost in presenting longer messages which were highly informative, quantitative and/or imperative, it might be worth this cost if drivers responded rationally to the messages. There is, we believe a clear trade-off between the extra expense in presenting longer messages and the cost of congestion. We have all read estimates of the cost of congestion. It seems very likely to us that the cost of presenting longer messages would be only a fraction of the costs assignable to congestion delays. Furthermore, there are no technologic barriers to the presentation of longer messages.

Message Length and Mode of Presentation

One possible mitigating factor occurs to us and that is the potential impact of requiring drivers to read or listen to longer messages. There is sufficient data now to strongly suggest that it is possible to divert drivers' attention away from vehicle control to an extent which jeopardizes safety. Drivers might simply not have time to read the complete message or even worse they might jeopardize their own and others' safety by fixing on the interior displays or external signs and not the roadway and other traffic. Just how much of a driver's attention can be diverted before safety is compromised, seems to be at least partly situation dependent. This is of course a question which requires a quantitative answer from future research.

The mode in which information is presented may be another issue which should be addressed. There may be benefits for use of head-up rather than head-down displays or perhaps even virtual displays which would permit viewers to read information without requiring them to focus in the near field (i.e., display the information at or near optical infinity). Or it might be better to use auditory rather than visual presentation of traffic messages. The point is that although it might require additional research relating to possible safety impacts, the additional cost may be paid for many times over by achieving a measure of traffic control which would substantially reduce congestion. The finding discussed here on the impact of message structure on drivers' behavior, would seem to warrant such consideration.

Message Meaning

Some of the findings pertaining to the reasons respondents selected a particular choice are interesting to consider. Perhaps the most surprising finding was that many of the respondents stated that they did not understand the advisory message. The advisories seem straightforward and we know that the respondents were literate. We suggest that when they stated they did not understand a message such as "Congestion Ahead" they did not mean that they did not understand the meaning of the words but that they could not grasp the implications of the message. That is they lacked understanding of how much congestion was present, how far ahead the congestion occurred, how much the congestion would delay them, and what they should do about the congestion other than add to it. The one case in which this line of reasoning fails is the case when the scenario stated that congestion was evident to their own eyes. This suggests that in this single case respondents at least knew the location of the congestion even if they did not know what it meant to the duration of their trip times.

This interpretation of the findings related to the selection of reasons is appealing since it supports, and is a part of, the same major finding that participants are more apt to act on advisories which contain more and better information. However, to be completely consistent we must suggest that advisory messages would be further improved if they contained even more and better information. We also need to assume that the repeated presentation of demonstrably correct and complete information would restore many drivers flagging confidence in the accuracy, completeness and timeliness of advisory messages.

Attitudes About Punctuality and Belief in Advisories

The distribution of responses to the punctuality scale demonstrated that the choices made and reasons for those choices given by our population of respondents cannot be due to a lackadaisical disregard for punctuality. Reasons for the choices made are far more likely to be due to the factors stated in the scenarios and to the structure of the advisories themselves.

The results from scaling respondents beliefs about the accuracy and timeliness of advisories showed that they recognized that there had been some errors and delays in the past. However, they also volunteered that they would accept future advisories because they believed that they would probably be correct. The data on choices made and reasons for them suggests that this would indeed be true for those cases where the advisories contained sufficient information that was at least in part quantitative and/or imperative. In Experiment 2 we extended the query to evaluate how strength of belief would be altered if drivers were told that there was congestion but they could not as yet see it. Would they act on the advisory message by exiting to an alternate route without the evidence from their own eyes that there was a problem on their main route? The answer was yes. They continued to demonstrate a high level of trust in the advisory.

Considerations

For both Experiments I and II we used specific road segments and selected a population which was thoroughly familiar with these roadways. By doing so we have limited the generalizability of the results obtained in this study. Specific road segments generally have inherent bottlenecks or geographical features associated with them which may inhibit or expedite traffic flow. There are often specific sections of a highway which become congested early or may be prone to severe congestion once slow-downs begin. Furthermore, persons who are familiar with a specific roadway are likely to be familiar with its patterns and frequency of congestion. Such persons may favor particular exits over others along the route based on; signal patterns on the associated streets, known short-cuts, or past negative/positive experiences. It may be that the pattern of indicated early departure from the main route, greater for few options than for many, was partially due to participant preferences over certain exit options (i.e., exits encountered later along the main route).

Additional considerations can be acknowledged in terms of the sample population selected. The fact that participants were familiar with the routes selected means that the number who would not depart the main route early, due to fear of becoming lost on the alternate route, was reduced. If drivers are unfamiliar with an area they are likely to be hesitant to leave the main route to embark on an unwanted adventure along back roads. In such cases tolerance for longer delays on the main route may be increased.

One final consideration should be made regarding the accuracy between what our participants have said they would do under the circumstances of the questionnaire and what they actually do when confronted with similar circumstances on the roadway. The chief shortcoming of this project is the fact that it is questionnaire based. Would drivers behave in actual driving in the way stated on a questionnaire? This is an important question. The positive results from this project strongly suggest that on-road testing to an extent sufficient to confirm (or to fail to confirm) these findings would be important. The Human Factors Research Laboratory intends to seek ways to conduct an on-road evaluation of the findings from this project.

CONCLUSIONS AND RECOMMENDATIONS

The idea that led us to undertake this experiment was shown to be correct. Drivers respond differentially to advisory messages based on the quality and quantity of information contained in the message. In particular quantitative and imperative information cause adaptive responses from drivers. By adaptive responses we mean that drivers would act to reduce congestion thus lowering trip times. Traffic controllers with this knowledge of driver behavior could then act to reduce trip times even further by using the control tools available to them (e.g., ramp meters, traffic signals at intersections and CMS/VMS). The major conclusion we can draw from this study is that when possible, advisory messages should contain quantitative and imperative information. We have also shown that messages which are incorrect have long term negative effects on drivers' adaptive responses. Thus we do not recommend deliberate use of inaccurate messages as a temporary expedient.

We feel there is a need to further explore the safety of portable and fixed devices designed to present traffic information. In particular, future research should address the effect of message length on driver performance. We are not advocating the use of excessively long messages in order to incorporate imperative or quantitative information. There is a practical and safe limit for traffic messages and information. What that limit is however, has yet to be determined.

Appendices containing sample questionnaires have been omitted for the sake of brevity. Requests for information regarding experimental apparatus may be directed to:

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